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ANIMAL HUSBANDRY.

In striking contrast to farming in the temperate zones comparatively little attention has been paid to livestock in tropical agriculture. According to the European concept of farming, agricultural prosperity is regarded as being largely bound up with the successful combination of crop and animal husbandry. In the tropics, generally, on the other hand, in relation to different climatic conditions, this useful combination has not been attempted to any marked extent. Hitherto, the chief use of animals in the tropics has been for draught purposes, and there has been little attempt to improve them as producers of meat and milk. Also, the lack of care bestowed in general upon any but working cattle is distinctly unfortunate. With, however, the rapid colonization of the tropics there has been a growing demand by Europeans for fresh meat and milk—shortages of such animal products have definitely occurred and the demand which has often amounted to a craving, has had to remain unsatisfied. Further, as agriculture develops the native will have perforce to turn from the hoe to the plough and for this purpose will need cattle. The relationship between crops, stock and farmyard manure is clearly understood in settled agricultural countries but seems to be little in evidence in the tropics where the continued opening up and use of tracts of land is taking a heavy toll of the original fertility of the soils. It may be remarked therefore that the time has come to study more closely the future prospects of livestock in the development of agriculture in the tropics.

Many reasons can be advanced to explain why animal husbandry has hitherto played a relatively unimportant part in tropical agriculture. Conspicuous among these is the shortage of good grazing lands. Further, as a fairly large proportion of the tropics is essentially concerned with the production of perennial crops, an extensive system of animal husbandry has not been required. In the northern hemispheres, on the other hand, the production of crops is mainly confined to annuals and animals are used to consume surplus produce and crops which are grown but are not sold for human consumption. Also the further north the country is situated the easier it is for animals to find food on which they can thrive. Here natural food owes its value principally to the long periods in which, on account of climatic factors, vegetation remains in the protein state of development, in contrast to the tropics where growth is speeded up so that the

less nourishing carbohydrate and fibrous state is quickly reached. Thus the relationship between plant and animal growth and climatic factors appears in the northern hemispheres to have reached its optimum. Another great handicap to the successful development of stock industries in the tropics is to be sought in the heavy incidence of disease specially due to parasitic pests and debility consequent upon the effects of the climate. No sooner have domesticated animals been introduced in districts where natural conditions would appear suitable, than they fall a prey to these enemies. Indeed it is sometimes impossible for stock to survive. Such districts which have had to be abandoned, therefore will only regain their potentiality as areas for livestock production when measures have been found to overcome the present difficulties.

In this connection the Empire Marketing Board has already supported the Onderstepoort Station in the Transvaal to carry out further veterinary researches; it has provided funds to conduct researches into the mineral deficiencies of pastures in Kenya while it has also drawn particular attention to some of the most vital problems, mainly disease, which at present are affecting the proper development of livestock industries in the tropics. Certain schemes have been submitted which, it is hoped, will in due course be carried into effect. Quite recently also the Empire Marketing Board has erected a quarantine station in the United Kingdom to help with regard to furthering the exportation of pedigree stock to overseas parts of the Empire.

Local Departments of Agriculture are also tackling livestock problems on the spot. Turning to the West Indies, Jamaica and Trinidad have been particularly fortunate recently in receiving a visit from Mr. Hammond of the School of Agriculture, Cambridge, who was appointed by the Empire Marketing Board to investigate the inheritance of milk and other characters in crosses between local and European breeds. The views which Mr. Hammond has already expressed have excited much interest and stimulated the desire for more knowledge on a subject which is, as yet, little understood. The results of his investigations should prove of much value in guiding those who have launched stock enterprises in these colonies. While conditions for stock production appear particularly suitable in parts of Jamaica, favoured as it is by its grazing lands, in Trinidad the position is not quite as propitious although it has been shown at the Government Farm that much can be done to improve the breeds of indigenous stock. Also, although there are practically no suitable grazing land districts in Trinidad it is satisfactory to find that already a number of dairies are operating successfully and supplying some of the local demand for fresh milk. There is nevertheless ample scope for increasing the local supply of animal products. Statistics of imported animal products show that over £450,000 was spent in 1928 on these products by the Colony which, for that year, represented just over 1/6th of its total exports of raw materials (*i.e.*, sugar, cocoa, &c.). This appears to be a very high figure and shows that there is room for the local stockbreeder to increase his production.

Success in livestock enterprises in the tropics, in our present state of knowledge, offers a number of difficulties. Animal husbandry may be said to be still in its pioneering stage. Little is known on methods of stock management and practically no reliable data are available on foods and feeding; much more knowledge is also required on the value of some local foods consumed by stock, while there is much need to explore the production and uses of new kinds of fodder crops. Other important questions that need study are those of water supply, the management of pastures, and parasitical diseases where it may be necessary to discover disease resistant breeds and to evolve new methods of control. With regard to the dairy industry it has always been a matter of great difficulty to produce milk under sanitary conditions in the tropics and more attention will have to be paid to the sterilization of utensils and to proper methods for cooling milk. This should be coupled with sound organisation. Lastly, the study of animal genetics will also involve a number of important problems. Careful selection of stock will have primarily to be the main basis of livestock improvement. There are two methods that could be adopted, the first would consist in importing selected animals from the temperate zones, acclimatising them and crossing them with local stock to build up a new breed from an admixture of the two; the second would consist in selecting local breeds and improving them by methods already evolved in the temperate zones. This would be a slow process. The former method has already been attempted and with success, specially in Trinidad. With few exceptions, controlled stock raising in the tropics is still in its infancy.

There are no breed societies and no herd books and it will be necessary, in future, to exhort people to select animals only for a certain purpose. The formation of herd books would appear to be vital, while further interest might be stimulated and knowledge gained by the organisation of more livestock shows.

It will be seen that the tropics afford many opportunities for pioneer work in animal husbandry. Economic possibilities in the more suitable districts for successful animal production should arise in future but before embarking on stock enterprises much attention will have to be paid to the solution of some of the problems already outlined. The 1932 Imperial Conference will probably examine the present position of the livestock industry in the tropics and take steps to decide on a uniform system of keeping milk records on the lines of the Ministry of Agriculture's scheme. Livestock also offers a very wide field for research in the tropics and as there is much to be done in that direction the appointment of a large number of livestock officers who could be trained at existing livestock stations appears very desirable and should be encouraged.

ANIMAL PRODUCTION.

The Influence of Natural Conditions on Animal Production.

By John Hammond,
School of Agriculture, Cambridge.

[*An address read at the 14th International Congress of Agriculture, Bucharest, June, 1929.*]

It is a law of nature that those wild animals best suited to their surroundings survive and crowd out those less suited. Similarly in animal production the natural conditions very largely determine the kind of production, for under the stress of economic competition those districts having natural advantages can compete more favourably in the world's markets. It is by adapting production to natural conditions that economic success is attained. The interchange of different products between districts forms the basis of trade, all districts thereby profiting from the natural advantages of each. With the evolution of modern transport this specialization of production in districts is increasing. It is the object of this paper to outline briefly the influence of natural conditions on animal production and to attempt to explain the fundamental causes in the light of recent scientific research.

It should be recognized that the main function of the animal in Agriculture (apart from draught) is to form a means of cashing those crops which are not salable for human consumption direct. There are large districts, situated for the most part in the tropics, where the animal (apart from draught purposes) plays but a small part in Agriculture, while in some parts of the temperate zones (the prairie wheat lands of Canada) the animal has not been exploited to the same extent as under intensive cultivation where rotational cropping is practised.

Since the animal lives on the plant it is to the effect of natural conditions on plant life that we should turn for an explanation of the local differences in animal production. The proportions of the plant change, not only anatomically but also chemically, as it grows; in the early leafy stages of growth the plant is mainly protoplasmic (high salt and protein content) with thin cell walls of digestible cellulose; with the fixation of more carbohydrates the flowering shoot is formed, to support which thick cell walls containing much fibre (indigestible cellulose and lignin) are formed, further carbohydrates produced being then transferred to the seed and the plant itself becomes relatively poor in proteins and salts and rich in fibre. Not only does the plant in its young growing state contain a high proportion of protein (a highly valuable and expensive feeding-stuff to buy), but, as Kühn has demonstrated with trefoil fed to cattle, and Woodman with pasture grass fed to sheep, the amount digested by the animal is very high owing to the small amount of fibre or cellulose that it contains:—

TABLE I.

Crop.	When cut.	Flowers of crop.	Composition—Per Cent. in Dry Matter.					Per Cent. Digested.			
			Protein.	Fat.	Carbo-hydrate.	Cellulose	Salts.	Protein.	Fat.	Carbo-hydrate.	Cellulose
Trefoil (Kühn) ..	20th May	Quite green ..	19·6	2·5	42·5	25·3	10·1	70·8	57·9	70·2	50·6
	7th June	Beginning to show	16·3	2·9	44·9	28·1	7·8	64·9	64·4	68·3	46·4
	20th June	Withering ..	13·2	2·8	48·4	28·8	6·8	58·7	60·1	66·2	39·7
Pasture grass (Woodman)	Young—cut with lawn mower		26·4	5·3	44·4	13·5	10·4	81·0	50·1	81·5	78·5
	Old—as hay ..		9·9	3·6	49·0	30·0	7·5	59·0	40·0	63·7	59·1

It is the local climatic and soil conditions acting on the rate at which these changes in the plant proceed that determine the suitability of the plant as a nutritive basis for milk production, fattening or merely rearing purposes, according as it is in the protein, carbohydrate or fibrous state of development, and so which largely determine the type of animal production that can be most profitably employed.

The various combinations of hot and cold temperature with dry and wet areas form the basis of climatic conditions; cold and wet, alone or in combination, prolong the maturation of the plant and consequently it remains in the early high-protein easily digestible stage for a longer time; these conditions also prevent complete maturation so that for example the feeding value of straw in the northern districts of Scotland and

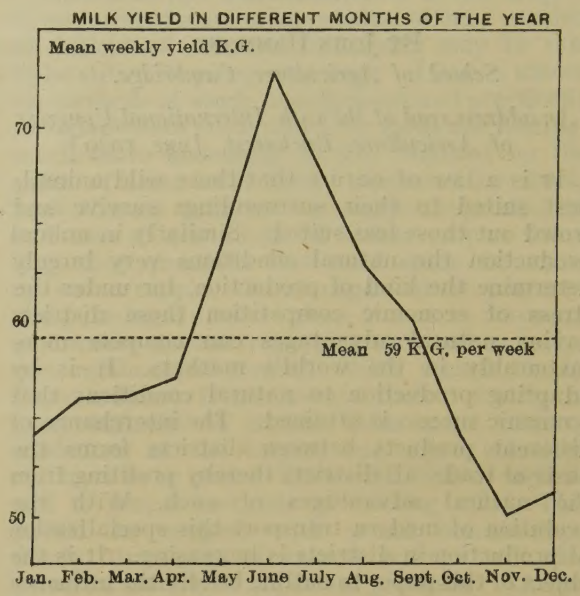
Scandinavia is much higher than that of straw from districts such as Southern England and Belgium where the warmer climate has led to completer maturation with greater yields of grain. It is consequently found that the animal plays a more and more important part in the agriculture of the country as we pass from the tropics to the poles. Similarly in any one district an increase in altitude when accompanied by moisture gives the same results, as may be instanced by Switzerland as compared with a similar latitude in the plains of France. The water supply is not necessarily limited to rainfall (Ireland and West of England) but may be available as a high water table in the soil (Romney Marsh in the dry east of England, Friesland and in river estuaries); in these districts pasture land predominates, for the delay so caused in the maturation of the plant extends the grazing season and so the return yielded from a given area.

So far we have dealt with animal production in general, now let us consider the requirements of cattle in detail. In the improved breeds of dairy cattle the nutritional demands made by the output of milk at the time of maximum production are very great; and, while even in the wild state the cow will store a reserve of fat in the body to supplement the food in times of privation, no great storage of proteins by the body exists to meet the demands of high milk production, and the whole has to be supplied daily to meet the output in milk or else the yield will be reduced. Grass in its mature form as hay will supply carbohydrates but it cannot, by reason of its bulk and the high proportion of the cellulose which it contains, be consumed in sufficient quantities to supply the proteins required. Concentrated foods rich in proteins may be given to supplement this, but these have to be purchased by the farmer and are expensive; it is those districts in which he can produce this type of food himself, in the shape of young growing grass, that dairy farming becomes economically important. Diagram I (from Hammond and Sanders) shows how the average yields of cows are raised when they are turned out to the young grass in the spring, and falls as it begins to get old and fibrous in July (from Cumberland, England, a grassland district). The curve shows the yield per cow per week which might be expected from a herd where an equal number of cows calve in each month.

These natural variations in the yield of milk at different times of the year are a source of inconvenience in maintaining a regular supply throughout the year when it is being sold for consumption as fresh milk and have to be met by calving a higher proportion of cows during the autumn months and by the introduction of the more expensive arable cultivation with a supply of roots for winter feeding. In warm and dry districts where the pasture soon dries up frequent cuttings of lucerne in the early stages of its growth (as in Central France) have made milk production possible in dry climates by a prolongation of the time over which the young growing plant is available for feeding.

Diagram I.

Comparative milk yields obtained from cows at different times of the year.



When the proteins of milk (as cheese or condensed milk) form the chief commercial outlet for the supply, the cows calve mainly in the Spring so as to obtain the nutritive advantage of the young grass at the time of their maximum production (Friesland); thus grassland districts are those in which not only cheese (in which the quality is better than from arable land) but also condensed and dried milks can be produced most economically. Movement of the cows up the mountains following the growth of the grass (as practised in Switzerland) still further extends the seasonal advantages of cheap production. Similar circumstances probably direct the wanderings of nomadic tribes in Africa and the migrations of flocks of sheep in Spain. Attempts are now being made to separate the cellulose from the proteins in grass by Ereky in Budapest, and by Woodman in Cambridge to preserve the young growing grass by drying, in a transportable form suitable for feeding all the year round; if commercially possible, these methods should supply optimum conditions throughout the year from grassland alone. The making of silage from young grass is also used for this purpose in Friesland, and from arable crops in other districts.

With butter production the requirements of a more even all the year round supply demand an extension of production into the winter months such as can best be obtained under arable conditions (Denmark). Since butter production also requires a rather higher carbohydrate content in the feed (Nils Hansson) the conditions of alternating sunshine and shower which favour production of carbohydrate by the plant (Jersey and Guernsey), and those bordering on districts suitable for fattening cattle, are most favourable for this purpose. From the point of view of animal production arable cultivation forms a means of prolonging the growth of the plant in a

ANIMAL PRODUCTION.

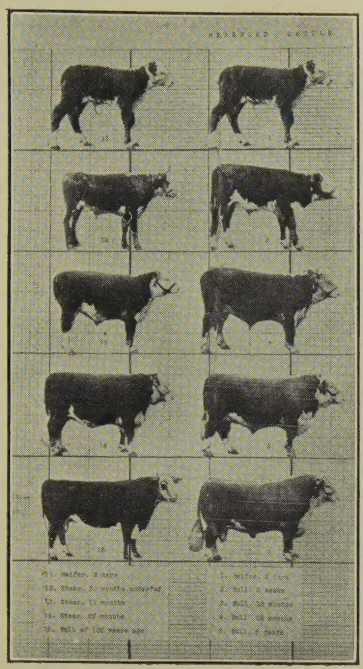


FIG. I.

The changes in the proportions of the body in Hereford Cattle.

In order to show differences in body shape as distinct from size, the photographs have all been reduced to the same height at the shoulders, so that the proportions are shown in relation to this measurement.

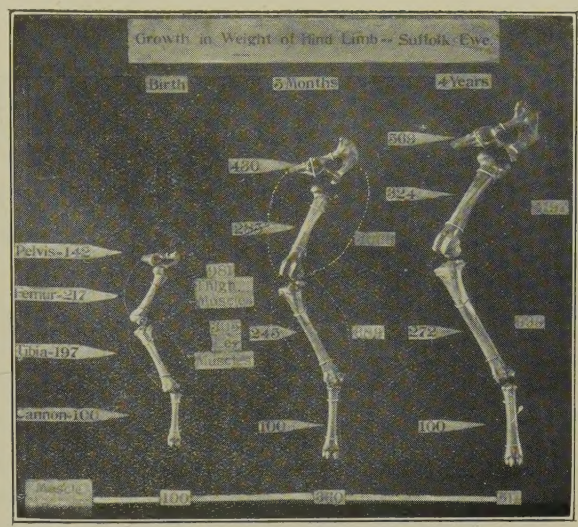


FIG. III.

Shows how the proportions of the muscles and bones in the leg of mutton change as the animal grows up. All weights shown as a percentage of the weight of the cannon bone.

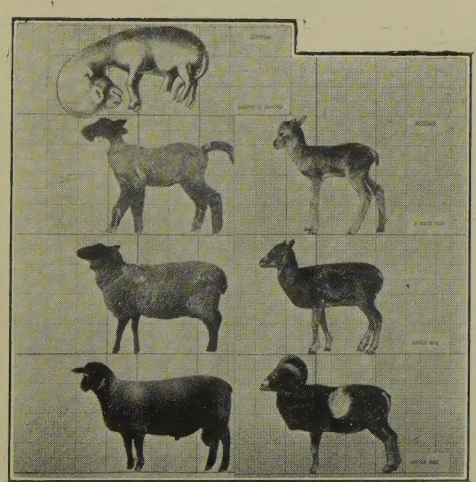


FIG. II.

Shows how the improved breeds of sheep (Suffolk) have been pushed to further proportional development of the body as compared with the wild type (Mouflon). The adult Mouflon ewe although much larger, is, in body proportions but little in advance of the improved Suffolk at birth.

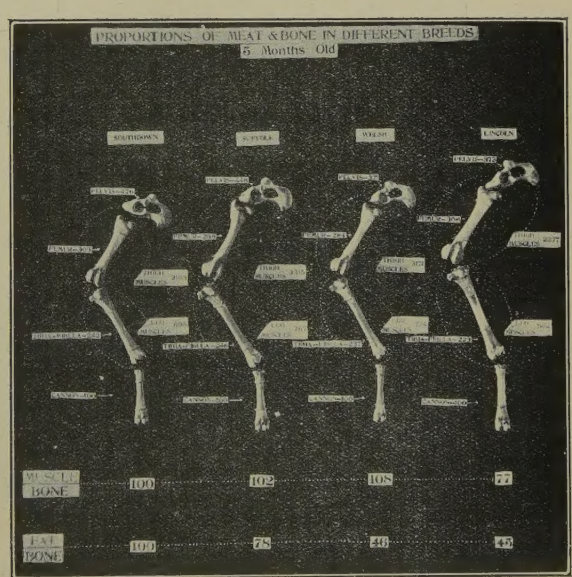
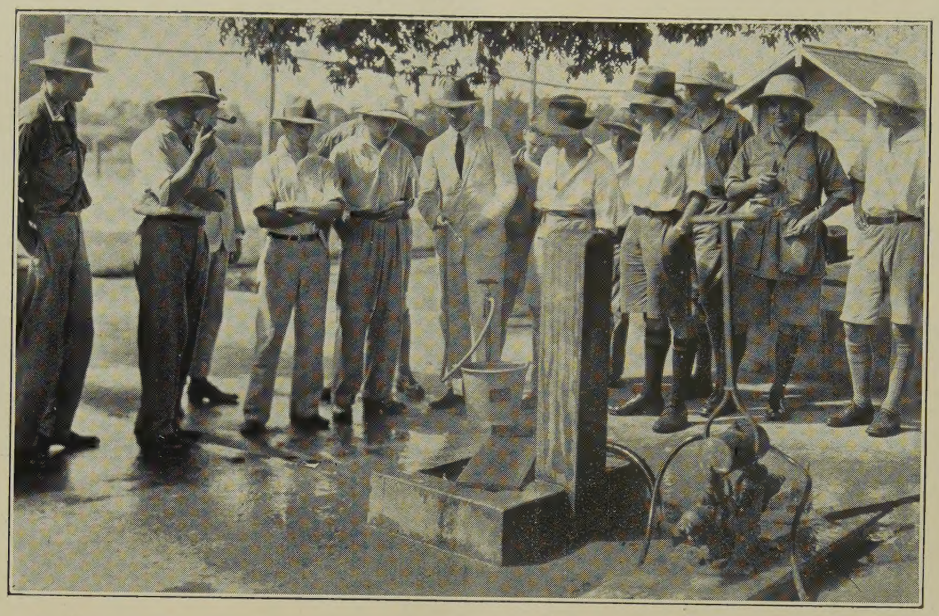


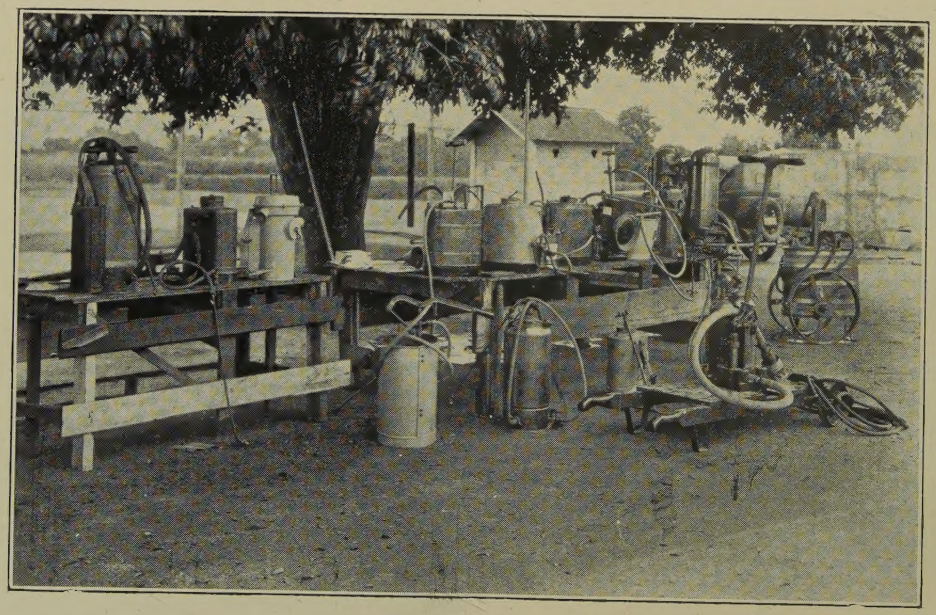
FIG. IV.

Shows how different breeds vary in the rate at which the proportions of the body change with age (early maturity). All wethers at five months old. Breeds of sheep (left to right). Southdown, Suffolk, Welsh, Lincoln.



Photograph by *Tucker Picture Co.*

1.—*Spraying demonstration at the College.*



Photograph by *Tucker Picture Co.*

2.—*Types of spraying machines.*

comparatively dry climate, and by so doing to obtain a greater yield of protein and carbohydrate feeding stuffs in summer as well as a more suitable supply of food for winter feedings. As an illustration from Great Britain—the West, a district of high rainfall, is predominantly pasture which is used for milk production (some cheese, and in the South, some butter and cream); in the Midlands, with a moderate rainfall, cattle reared in the West are fattened on pasture in summer; and in the East, a district of comparatively low rainfall, arable cultivation is predominant and cattle reared in the West are fattened from roots in winter, while in former times some districts (Suffolk) were butter producing.

The food consumed by the animal is used for (1) *Maintenance* to supply the energy to keep the animal alive and well, and any surplus above this is then available for (2) *Production* in the shape of increase in weight, fattening, milk production, &c. Since the animal has a limited stomach capacity, bulky foods containing much fibre (such as hay) do not supply sufficient surplus for much production and concentrated food containing much nutrition in small bulk (cakes and meals) have to be added to the ration where high production is required. Since production is commercially profitable while maintenance is not, and since the overhead charges such as accommodation and labour are approximately equal, the greater the production, the more profitable is the undertaking, provided the concentrated foods can be produced by the farmer himself and he has not to rely, as at present, on purchased industrial bye-products. Wood has shown that, even in a highly cultivated country like Great Britain, if the total production of crops available for cattle feeding be taken, and an attempt is made to compound a balanced ration suitable for high production from them, it is found that the proportion of coarse (fibrous) fodders to concentrates or productive fodders is in the region of 3:1—a proportion on which the production output will be very low if no concentrated feeding stuffs are purchased. Attempts are now being made to perfect methods for producing these concentrated foods on farms

In countries with hot dry climates in which the fibrous stage of the plant is quickly reached (parts of India) it is not possible to obtain high production until methods of irrigation (as in Egypt) or other means are taken to prolong or conserve the young growth of the plant. Recently it has been found that in the dry parts of Australia, where the soil is deficient in phosphates, the addition of this has increased the growth of the herbage, for the plant uses water as a means of obtaining its foods and when its food is plentiful, less water is required for its extraction from the soil. When a large proportion of the food supply of the animal consists of coarse fodders, growth and fattening cannot proceed at the same time, and consequently the method of keeping animals on a poor ration ("storing") until fully grown and then fattening them has been practised for a long time and in many districts. This has led to cattle being reared in poor grassland districts and then being transferred to fertile districts to be fattened (in the United States from the Middle West to the region of the Corn belt). This system involves both greater total consumption of food by the animal and a carcase of meat less suitable in size and in the proportions of the joints than does the intensive system of fattening coincident with growth and the production of early maturing meat, but under the conditions existing at present in many districts it is the only possible method.

In producing the highest quality meat a high proportion of muscle and fat to bone and offal parts, and a high proportion of the best joints, are required. Fig. I shows (on the right) how the proportions of the animal change as it grows up; at birth the calf is all head and legs while the body is short and shallow as compared with the adult. Those animals which pass through these age changes in proportion quickest, and to furthest extent, are those which are the most valuable for meat production (Hammond and Appleton). The effect of putting an animal on a poor ration during growth ("storing") is to encourage the growth of the early developing parts of the body (head, legs and offal parts) and retard the later growing and more valuable parts of the carcase: compare No. 12 (left) at 30 months old kept in store condition (from an experiment by Trowbridge, Moulton and Haigh) with No. 14 (left) at 22 months old and well fed from birth.

Since under-nutrition, or feeding on too bulky food, retards the full development and most valuable parts of the animal, it is difficult to make proper selection of breeding animals in those districts where the food supply is below the innate physiological capacity of the animals for growth, milk production, &c. Consequently we find that the breeds most valuable for production have arisen in areas where the natural nutrition is suitable for the purpose; for work, the Simmenthal cattle from the moist fine pastures of the Swiss valley; for milk, the Friesian from the low-lying pastures of Holland; for beef, the Aberdeen Angus from the good root growing land of East Scotland, and the Hereford from the good pasture land of England. Although these breeds have been extensively used in other areas with advantage, yet we find that breeders continually go back to the district of origin for fresh stock, for in most cases the improvement by selection is quickest in these naturally suitable districts. Governments and owners starting stud farms to breed males to improve the native stock would do well to select suitable localities in order that progress in breeding should be as quick and inexpensive (without recourse to many purchased concentrated foods) as possible.

The effect of natural conditions on the size of the animal has an important bearing on production. In districts of good nutrition a large animal is more economical for production than two small ones, because the overhead charges in accommodation and labour are less and because the energy required for maintenance, following as it does surface area and not weight, is also less in total amount. Under conditions, however, where the

herbage is fibrous and scanty, such as in dry climates or on poor soils, a large animal, because of its larger actual maintenance requirements, will have less proportional surplus nutrition for production than a smaller one. Thus in districts of scanty herbage cattle tend to give way to sheep and goats, and eventually in barren heath land and dry climates to rabbits (Australia). The introduction of sheep, into the barren highlands of Scotland, which were formerly sparsely stocked with cattle only, resulted in a greatly increased prosperity in these districts. By adopting a smaller and lighter type the breeders in the dry sandy-land provinces of Eastern Holland have maintained the production of the black and white cattle, which would not have been possible had they striven to maintain the large type existing in Friesland and North Holland. In the dry South-Eastern counties of England the small dual purpose (milk and beef) Red Poll takes the place of the larger Shorthorn of the better grass land in the North and West. By keeping the size of the animal small, the Southdown sheep has been developed to a high degree of excellence for mutton conformation on the scanty herbage of dry chalk downland. Breeders in districts of scanty herbage would do well to decrease the size of their stock when aiming for high production and, when introducing animals from districts of better nutrition, to select the small ones rather than the large types favoured in those districts.

So far we have considered the influence of natural conditions on the herbage and the direct effect of this on the animal, but natural conditions also affect the crops produced for human consumption and, since it is on the inferior qualities and bye-products of these that the pig depends for its food supply, it is on the supplies of such bye-products that the profitableness of pig-keeping depends. In England during the war and in fairly recent years in France, when much of the milling offals were incorporated in the bread of the people, pig-keeping ceased to be profitable and the pig population greatly declined. Conversely in those districts where supplies of inferior corn (Scandinavia), potatoes (Germany), &c., are produced as a bye-product of their production for human consumption direct, the pig becomes profitable, for meat produced as a bye-product in this way is able to compete more favourably in the world's markets than that which is produced as the main source of output. Moreover, as pointed out above, the chemical composition of the feeding stuffs available also economically determines the nature of the commercial outlet for the supply and the type of animal produced. For example, the corn belt of the United States, with a supply of carbohydrate food (maize), has produced the lard type of pig, where fat is the main product; while in Denmark, where skim milk and whey from the dairy industry supplies a staple ration of protein foodstuffs, bacon is the chief product, for lean meat is the main consideration in this type of produce.

A study of the effects of natural conditions on the plant in relation to the science of animal nutrition would do much to increase the profitableness of production in many districts where animals have hitherto played but a small part in the agricultural economy and by so doing would raise the general standard of human nutrition and development in the same way.

Addendum.

In order to illustrate in rather more detail the principles outlined above additional figures have been added. (*See* page ix.)

The way in which the conformation of the animal has been developed for meat purposes by selection in combination with better feeding conditions is illustrated in Fig. II. The wild sheep (Mouflon) changes in shape as it grows up, but these changes in proportions are carried still further in the improved breeds (Suffolk), so that the improved breeds pass through the proportions of the wild form early in life: for example, the proportions of the adult wild Mouflon ewe are but little in excess of that of the improved Suffolk at birth. The way in which these changes in conformation improve the animal for meat purposes is illustrated in Fig. III. As the animal grows up the upper bones of the leg grow more rapidly than the lower: similarly the muscles grow more rapidly than the bones. In this way the proportion of meat to bone rises as the animal grows up. An early maturing animal from a meat point of view is one in which these changes in proportions occur rapidly. Fig. IV shows the leg of mutton from four different breeds at the same age, and it will be seen that while the leg of mutton on the left is salable because of the high proportion of muscle and fat to bone, that on the right (although the same in actual weight) is not fit for the butcher because of the low proportion of fat and muscle to bone. Since the more valuable and later maturing tissues and parts of the body (fat and muscle—loin and back) suffer more from under-nutrition than the less valuable and early maturing parts (bone—head and legs) the development of the valuable parts cannot be selected for unless the nutrition is available to form them. This can be done by improving feeding conditions or by reducing the size of the animal, combined with selection for breeding purposes of those individuals which show most proportional development for their age.

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TRANSPORT IN THE TROPICS.

By Lieut.-Col. Philip Johnson, C.B.E., D.S.O.

There is a very close association between tropical agriculture and transport. In industrialised or partly industrialised countries, the demand for transport is so consistent and so large and the profits of industry are collectively so great, that there is no difficulty in providing the most efficient means of movement known, irrespective of the capital cost, for countries so situated. In countries whose prosperity is largely or wholly dependent upon agriculture, the situation is very different. The volume of traffic may be too small to justify large capital expenditure on roads, railways or canals. Also, the demand for transport is always intermittent. It may be very great for three months in the year and negligible for the remainder. This is peculiarly the case with tropical agriculture where the products of the soil, measured in tons per acre of crop to be moved, is far greater as a rule than in more temperate climates. Thus tropical agricultural transport presents even greater difficulties than obtain elsewhere. In addition there is the ever present economic question of providing a means of movement, which makes it possible to transport comparatively low priced agricultural products for considerable distances at an overall cost which will result in their being marketable at destination.

Out of the foregoing, a situation has arisen to-day in the British Empire, and more especially in its tropical and semi-tropical portions, which is very far from satisfactory. The transport demands of agriculture are insufficient to justify the enormous cost of roads and railways and in the absence of these, agriculture languishes for want of a cheap means of movement. In those localities where navigable waterways fortunately exist or where railways have been built for serving mines or for administrative or military purposes, the means of movement thus provided develop a narrow strip of territory in the immediate neighbourhood. The strip so developed is limited to a width of about 24 miles or 12 miles on either side of the railway or navigable waterway. Beyond this distance the cost of transporting agricultural produce is normally prohibitive with the exception, perhaps, of high priced products, such as cotton or wool, which it is possible to transport economically over greater distances.

In the past few years innumerable attempts have been made all over the world to remedy this situation, and to develop those parts which lie remote from any established means of movement, by utilising mechanical transport of the type which is common in highly developed industrialised countries, equipped with good roads. In doing this it has not been fully realised that vehicles designed for service over roads which have cost upwards of £10,000 a mile to build and which are very costly indeed to upkeep, are not of necessity suitable for operation over the so-called roads which are all that can be maintained under the average tropical agricultural conditions. Such "roads" or routes fluctuate between a narrow trail from which the jungle has been cleared with the provision possibly of a slight amount of drainage, and a "road" which is nothing more than a few inches of gravel or laterite over the earth surface with no foundations worthy of the name, no proper drainage, no curbing to prevent "spread" of the surface and inadequate provision for upkeep. Under these conditions it is found that the ordinary mechanical vehicles as used on roads in England, for instance, while they can and do operate with apparent success for a short time, more especially in dry weather, are quite unsuitable. When the traffic develops to any appreciable volume and when it has been in operation for a few months or a year, it is found that the excessive loads imposed upon the surface traversed has resulted in its complete destruction. This destruction is, of course, more rapidly brought about in some cases than in others and depends largely upon rainfall, the extent to which drainage of the route has been provided for, the weight of the vehicle, types of tyre employed, &c. In all cases, however, the result is ultimately the same. In some parts of the world, notably perhaps Uganda and the Gold Coast, the average condition of the so-called roads is comparatively good. Here, fairly satisfactory results from some points of view are attainable. Suitable material for the surfacing of the routes is available and the traffic is light, being wisely restricted to vehicles equipped with pneumatic tyres and not exceeding a certain weight. These, however, are the best conditions and they undoubtedly compare favourably with those where huge areas of land entirely suitable for agricultural operations lie completely neglected for want of a reasonably efficient and cheap means of movement.

The importance of cost in relation to tropical agricultural transport is a consideration which practically over-rides every other. If the cost of moving a crop is say one shilling a ton mile and it is possible to expend ten shillings a ton on the transportation of the crop, while still leaving it a remunerative business for the producer, then the economic radius from any market centre in which the crop can be grown is obviously ten miles. If the cost of transport can be reduced from one shilling to sixpence the economic radius is at once doubled and the economic area quadrupled, the area increasing as the square of the diameter.

It is difficult to estimate with any degree of accuracy the average cost per ton mile which tropical agricultural produce has to bear when movement must take place over such routes as have been described. Generally speaking it is seldom less than one shilling a ton mile and very often much greater. We have seen that it is hopeless ultimately and finally to attempt to reduce these figures of cost by the use of vehicles common and serviceable enough on well made European roads carrying loads of 3, 5, 10 or even 15 tons at a time, because sooner or later such

vehicles must destroy the routes they traverse over. Also, that it is an economic impracticability to provide the type of route which would make the use of such vehicles feasible. Yet it is only by increasing the load carried at one time that a radical reduction in cost per ton mile can be looked for. The problem is therefore to provide a type of vehicle for tropical agricultural transport which will not, by its passage, destroy even an earth road surface but will rather tend to consolidate and improve it and yet will carry or haul, at one time, a sufficiently large load to make the cost of transport economic, even for considerable distances. This is a problem to which, in the past few years, a considerable amount of thought and effort has been devoted. The British Government appointed in December, 1929, the Oversea Mechanical Transport Directing Committee for the special purpose of encouraging a solution. A brief description of what it is hoped may provide the solution of the problem is given below. Steps in the direction indicated are being taken at the present time and there would appear to be some prospect that in the not very distant future an appreciable measure of success will be attained.

The way in which it is proposed to solve the problem outlined is to provide a vehicle having a sufficient load capacity to ensure low cost per ton mile. For a variety of reasons the preferred figure is 100 tons. Anything less than this tends to increase the cost per ton mile without compensating advantages and anything much greater would place the vehicle too largely in the realms of experiment. The proposal is to carry the load of 100 tons in four 25-ton trailers hauled by a tractor weighing itself about 25 tons, the weight necessary to secure the required adhesion for the hauling of the load.

To provide for the essential requirement that the route traversed, even if only an earth surface, is not destroyed but is improved by the passage of the vehicle, no part of it would impose upon the ground a greater pressure per square inch than 12 to 15 lb. It has been demonstrated conclusively by a large number of tests that such a pressure is not destructive to an earth surface provided always that it is in moderately dry condition. This indicates in those countries at any rate, where considerable rainfall is common, a certain amount of drainage of the route, unless the traffic is confined to the dry periods of the year which in many cases is a perfectly feasible thing to do. To design a vehicle even of the gross weight entailed by the carriage of a load of 100 tons with a lower pressure than 12 to 15 lb. per square inch is quite conceivable though somewhat impracticable. It would mean, were the pressure for example brought down to 5 or 6 lb. per square inch, a very considerable additional capital cost to meet conditions which are very rare. There are, of course, circumstances in which there is a certain demand for transport under ground conditions where pressures exceeding 5 or 6 lb. per square inch would be excessive but they are sufficiently rare to justify their neglect. It should be understood that the design of the vehicle contemplated is such that the pressure is truly distributed over the ground surface when this is flat or reasonably so, but that if projections from the surface are encountered, then the pressure on these projections is greatly increased, even up to the full weight of that portion of the vehicle which comes in contact with them. The effect of this feature of the design is such that a remarkable road rolling effect is obtained, the inequalities of the ground being smoothed out in a rather similar manner to that effected by the conventional road roller. Thus not only is the most economical form of transport obtained, but a smooth and level surface consolidated by the weight of the vehicle ensured, greatly facilitating transportation by light mechanical vehicles such as motor cars and small load carrying vehicles which are, of course, always required in large numbers to deal with mails, light goods, passengers, &c. The important item in this connection is to ensure that these small vehicles are fitted with low pressure tyres of a type which will do a minimum of damage to the surface created by the 100 ton vehicle which would be the main, but not the only means of movement.

It will be clear that such a roadless train would function largely in substitution for railways and well built roads and would form the arterial method of movement for the development of agricultural areas. Figs. 1-3 (page xi) give a general idea of the proposed train. It could be operated by a variety of prime movers such as petrol, steam, producer gas or Diesel engine. The latter is preferred for the majority of circumstances as being in the generality of cases probably the most efficient and least expensive. An engine of 300 to 400 H.P. is required. Such a tractor is by no means impracticable as tanks for military purposes have been constructed on rather similar lines of higher horse power, greater weight and having speeds up to 30 miles per hour. The proposed train would, on the other hand, be limited to an average speed of about five miles per hour.

It will be within the knowledge of many readers that all conventional endless track vehicles of the types which are commonly known, are subject to the criticism that the pin joints which link the elements of the track together, are not only very inefficient in operation but very vulnerable to wear and tear, making the cost of upkeep almost prohibitive. Were it not for the fact that this difficulty in the last few years has been eradicated in the design of track now being largely used, it is quite probable that the suggested scheme would fail on account of the difficulty referred to or its usefulness would be very greatly minimised. What is referred to is the substitution for a pin joint in endless track construction of blocks of rubber in compression. This type of design is coming rapidly into large production as it has been conclusively demonstrated that the joint, being practically frictionless, leads to great overall efficiency, that adhesion with the ground is greatly increased over any pin jointed type and that the life of the rubber joints

is many times greater than any possible pin construction. Though the ultimate life of these joints is not as yet known, and will not be, for several years to come, sufficient progress has been made to demonstrate that it is certainly many times that of any pin construction and that, if and when destroyed, the joint can be renewed by unskilled labour at small expense. Another vital point in the construction of the tractor is that it should not damage the surface of the ground when turning. In the conventional endless track vehicles it is customary to steer by skidding the vehicle round bodily in contact with the ground, the tracks being laterally rigid throughout their length. This method, of course, has a very destructive effect upon the ground surface. It will be observed from the illustrations how steerage is obtained by laying the tracks in a curve thus avoiding all skid effect. This principle has been exhaustively tested on machines for military and other purposes. Yet another point, of course, is that the underside of the track plates where they make contact with the ground must be smooth, *i.e.*, must not be fitted with the spuds or grousers which are common practice where such machines are used for agricultural operations. With the rubber jointed type of track it has been found that with a perfectly smooth underside to the track plates all the ground adhesion required is obtainable and that up to 80 per cent. or more of the weight of the vehicle can be given off in the form of drawbar pull. Therefore there is no necessity to destroy the surface traversed by providing for any excrescences on the underside of the track plates.

Every detail of the design affecting the economical and efficient working of the machine under the conditions visualised has been considered in detail and experimented with exhaustively for many years past and the design of the machine put forward is based upon the experience thus gained. A number of estimates of the cost of working have been prepared and after making the most extravagant allowances for expensive staff, repairs, loss of time, &c., these estimates show that a figure of cost per ton mile can be obtained which is not greater in most cases than that which obtains on the average with Colonial railways. It is, of course, obvious that with vehicles of the type described, a highly trained expert staff would have to be employed. The conditions are much the same as those which are obtained at sea, where, in order to ensure efficiency and freedom from breakdown, a highly trained staff is employed to operate the propelling mechanism of the vessel.

The effect in practice of the employment of 100 ton trains as feeders to existing railways and waterways and as extensions to these means of movement, operating at a cost per ton mile similar to that obtainable on railways, can be realised fully, perhaps, only by those who are familiar with the difficulties now facing those employed in tropical agricultural districts situated at a distance from established railways or navigable rivers. At comparatively trivial expense cheap transport can be provided which will have the effect of opening up to development, areas which are now entirely unproductive. The costs of tropical agricultural produce will be reduced and the consumption stimulated. New and profitable enterprises will be provided by such development which should be of material assistance in dealing with Empire unemployment problems. The root cause of our unemployment is not that the total population of the British Empire is too great; probably with the area at our disposal we could increase our numbers tenfold, given better distribution. The problem is really the development of the neglected portions of the Empire which can only be done by the provision of cheap transport facilities.

RUBBER RESEARCH IN SUMATRA.

In Vol. LXXIII, No. 5 of the *Tropical Agriculturist* a paper by Dr. C. Heusser of the A.V.R.O.S. Proefstation is reprinted describing the tapping results of different legitimate seedling crosses of *Hevea*. The paper is of great interest, not only because it gives the first reliable evidence of the value of seedling crosses as planting material but also shows that the possibility of discovering very superior mother-trees among such crosses is large.

The tapping results of 1,450 seedlings comprising 30 different combinations of 17 mother-trees are given. Briefly, it has been shown that these seedling crosses have yielded in the third tapping year more than twice as much as the control seedling plot and, it is estimated, more than 40 per cent. as much as average estate yields at the same period. That is based on the total yield of all crosses. Certain crosses have given much higher yields. All the crosses containing No. 157 either as the male or female parent have given high yields, a fact which implies that this tree or clone carries the factors which determine yield in a purer form than is usual. The discovery of tree 157 is a valuable one, and seed from one of the crosses containing 157 may be considered as planting material equal in value to the best bud-grafts.

The highest-yielding seedling has been numbered 317 and was produced by the cross 165 × 161. In the third tapping year (that is, at eight years old) it yielded at the rate of 91.9 gm. per tapping. Another seedling yielded 86 gm. These and other seedlings will form new mother-trees to be used, among other purposes, for clonal reproduction. In considering yields of these crosses it must be remembered that the mother-trees used had not, at the time the crosses were made, been tested by test tappings of their bud-grafted progeny. They were unproved mother-trees and since then, apparently, none of them except tree 49 finds a place in the list of recommended A.V.R.O.S. clones. It can confidently be expected that the yields of crosses of proved mother-trees will be much more satisfactory.

COTTON RESEARCH WORK.*

[*We publish below extracts from Dr. J. C. Willis' valuable summary of the Reports received from cotton experiment stations during* 1928-29.]

Improved Cotton Varieties.

THE feature of the year in regard to breeding work is the success which has attended the growth of the variety known as U. 4, which was first selected by Mr. Parnell, the Corporation's plant breeder in South Africa, from a variety that is believed to have come origially from Uganda. This strain is now itself already in process of improvement by further breeding and selection in several places. The work most urgently required in South Africa was breeding against jassid and this was at once put in hand, and with great success, U. 4 and other jassid-resistant varieties being produced by a piece of selection work of the highest class. The present reports, both for South Africa and for many of the dependencies to the northward of it, deal very largely with the extension of work with U. 4, which has proved to be the best of the jassid-resistant varieties. It is described as "a remarkable strain, possessing, in addition to jassid-resisting qualities, drought resistance, prolific flowering capacity, quickness in forming buds and setting fruit, freedom from shedding, and in the bulk, which is far from being uniform, a large number of individuals with excellent lint characters and high ginning percentage."

Not only has it done well in the Union of South Africa, but also in Rhodesia, where it seems likely to form the parent variety for selection. In addition to being resistant to jassid, it has proved a first-rate cropper, giving yields up to and exceeding 1,500 lb. per acre of seed cotton. In Swaziland it has been so successful that it is expected that no other strain will be planted in the coming season. In Southern Rhodesia an unfavourable season subjected it to a severe test, and it is stated that "in a really favourable season we should be justified in expecting returns from U. 4 cotton far in advance of anything which previous experience of other cottons in Southern Rhodesia has warranted in the past." In Northern Rhodesia U. 4 gives promise of being able to withstand local conditions, and it is now being multiplied up for distribution. In Nyasaland also the strain seems successful and it seems probable that Nyasaland will have as much reason to be grateful to Mr. Parnell as has Southern Rhodesia, since this strain has in the past season shown itself as suitable for Port Herald as for Makwapala.

This is really a wonderful record for a new plant variety, and the Corporation, and all concerned, may be warmly congratulated upon the success attained, a success which bids fair to bring South Africa and Southern Rhodesia into the list of important producers of cotton in the Empire.

In Nyasaland, in addition to U. 4, Over-the-Top is still under trial. Although it is showing "increasing difficulty in coping with conditions" at Makwapala Station itself, this variety has done well in neighbouring districts.

Going further North, in Uganda progress is being made with re-selections from existing strains, that known as S.G. 27 being the most promising, while S.G. 29 gave good results in several places. Of the newly imported varieties, Acala seemed promising, and one plant was selected for the progeny rows.

In the Sudan, the disease known as leaf-curl became formidable last season in some parts, and breeding against it may have to be carried out. Some indication has been obtained of a connection between jassid-resistance and leaf-curl immunity, and if this proves well founded, U. 4 may afford a good basis for further work: experiments with it have already shown that it retains its quality of jassid-resistance.

It is unfortunate that hybrids of Sakel x Sea Island, which were providing some especially promising material for future propagation, appeared to be very susceptible to leaf-curl and had to be scrapped. Resistance to this disease seems commoner in cottons of American type and in native Sudan cottons. These are accordingly being used in hybridisation work.

Among American cottons that may be useful for those parts of the Sudan where cotton is grown under rainfall, a strain of Delta Webber, with more upright habit of growth, has given satisfactory results in experiments, and over 40 acres of it are being grown this season, under the name of Delrect, as the first stage in bulk propagation.

In Fiji the breeding work is concerned with both Sea Island and the Kidney variety brought from New Guinea. The former variety suffered this year from the effects of a wet season. Owing to the small market that exists for this type a few selected strains only are being grown, and the work of the Station was directed chiefly to the work on Kidney cottons. These trials have been continued, and in the past year the variety K3-2 seems on the whole the most promising, and it is being improved and multiplied up as rapidly as possible. Incidentally it would appear that selection work for jassid-resistance may prove to be as well worth while in Fiji as it has been in other countries.

In Queensland the exceptionally unfavourable season almost completely spoiled the breeding work last year, but some valuable information was obtained on such factors as plant growth and flower counts.

But, as stated last year, to breed improved cottons that shall be adapted to their several environments, though on the whole the most important thing, perhaps, is not the only line of

*Reports received from experiment stations during 1928-29. Issued by the Empire Cotton Growing Corporation, Millbank House, Millbank, London, S.W.1, price 2*s.* 6*d.* post free.

attack upon the general cotton problem. In South Africa the industry might probably have died out had not a jassid-resistant strain been discovered and developed, but in Queensland, for example, bearing in mind the high labour costs, to reduce the general cost of working and if possible also to increase the efficiency of the several farming operations is perhaps the most desirable thing. Consequently, in the report from that country much space has been devoted to cultural experiments having this object.

Much similar work is recorded in many of the other reports. For instance, in South Africa it is noted that fallowing depresses the early growth of the cotton.

Planting Distance Experiments.

In a great number of stations trials were made to find the best distance for spacing the plants in the rows, spacings of 6-12-18-24 inches being tried. In some places there was found to be no very great difference, though in Swaziland and in Queensland it was thought that the closer spacing was rather the better, as indeed is normally the case in the United States of America, where, however, the boll weevil is a determining factor, that does not occur in the Empire fields, in necessitating early maturation.

Other important experiments deal with the best time for planting, and in general it was found that earlier (but not too early) planting gave better yields.

A number of other experiments of this kind are to be found described in various parts of the reports. For instance, in Queensland planting in hills three feet six inches apart was found to be undesirable as compared with planting in drills and thinning to two feet apart, while thinning was found more advantageous while the plants were still comparatively small. Experiments were also conducted at several stations on the results of manuring and of green manuring.

In Fiji and at Candover (Natal) ratooning was tried; the results were unsatisfactory as regards quality and quantity of lint, though there is, of course, a saving on labour.

In Nigeria experiments are described on cultivation by means of cattle which have not been widely used for this purpose there as yet. The experiment in co-operative farming which is being carried out in that country in connection with the Corporation's seed farm is also of considerable interest.

Physiological Problems.

In South Africa, Sudan, &c., general physiological problems have been attacked. It was observed that with later planting, though the growth might ultimately be much the same, the number of flowers was markedly less. A high degree of correlation was found between temperature and growth-rate and flowering. In the Sudan it was found that a low ginning out-turn appears to be associated with deficient soil moisture, and that suppression of fruiting branches under conditions of excessively high temperature is due to their actual conversion into vegetative branches which usually remain in a partly developed condition, described as "monopodial tufts." Work is also being done in the Sudan upon the comparative fertility of the different layers of the soil, upon bud shedding, and upon "blind seeds," which appear to be due to lack of water.

Crop Rotations.

The most important general question that comes under this heading, and is perhaps best dealt with here, is that of the rotation of crops—for, to make a permanent success of cotton (in the same sense as, for example, the "root" crops of turnips, potatoes, and the like, are a permanent success in Great Britain), it must be made to form one member in a rotation of crops, and not the sole crop that is taken off the same ground year after year. One difficulty which confronts those engaged in this work is that in the various countries in which cotton is now established in the British Empire conditions differ very much, and a rotation that may suit one may be quite unsuitable to another. A special obstacle in some of these countries is that with the hand-to-mouth life of most of the indigenous population, each crop in the rotation must itself be one that will commend itself to the native as being worth while to grow, either as food or as a money crop.

A great many experiments with rotations are described. In South Africa, for example, three promising crops have been found—tepary beans, soy beans, and sunflower—for all of which, but especially for the second, there is a good market. It remains to determine the best spacing, time of planting, and so on, and the best method of incorporating these crops into a series that will form a really good rotation (like the English four-crop course), keeping the soil in good condition and draining food from it at a fairly evenly balanced rate, having regard to its actual constitution. There is evidently still a great deal to be done, and it is not yet even certain that these crops are sufficiently distinct in their requirements, but a good start has been made.

At Ingwavuma (Swaziland) groundnuts, which may almost be regarded as "roots," seem to be doing well, also sorghums, which might correspond to wheat or barley in the English rotation. Sunflower, groundnuts and two kinds of beans have done well in other parts of Swaziland also. At Candover (Natal) buckwheat—another crop with a good market—was found to do well in addition to those already named.

In Southern Rhodesia and elsewhere, maize—a crop with an unlimited market—has already been found to form a very good rotation with cotton, though probably a third and even a fourth member might with advantage be included. Pigeon-peas, tobacco, and maize are on trial in Nyasaland; beans and millet have been found useful in Nigeria, and so on.

Thus the outlook for the discovery of satisfactory rotations that include cotton may be described as distinctly promising, and the next problem may be to persuade the growers to make use of the results obtained. This question of how the results of the experiment stations can best and most expeditiously find their way into general agricultural practice is well known in this country, and is indeed doubtless nearly universal: it can only be said that each Station is probably best able to devise for itself the means best adapted to the cultivators in its district.

Pests and Diseases.

Turning finally to the matter of pests and diseases, the most widespread and damaging pests are the bollworms. In general, it may be said that the bollworm attacks last season were light, but there were bad ones in Nigeria, Southern Rhodesia and Candover (Natal). In Southern Rhodesia the attack of American bollworm drew special attention to this pest, and it is considered likely that it may be countered by selection of prolific and early-maturing strains. Light trapping was tried on a large scale upon the Estates of the Premier Cotton Company of South Africa, and details are given of the work carried out. A considerable capture was made of the moths of the Sudan bollworm, especially when the acetylene light was exchanged for electric, but the American bollworm was less affected.

The next most important pest is perhaps the stainer—and the attacks of this also have been light last season, except in Northern Rhodesia, where trapping was tried with some success, and at Candover (Natal), where it was found that the early-planted cotton suffered least.

Other pests that deserve special mention are the corn-ear worm, which is very serious in Queensland when the cotton is planted late, and aphis in Nyasaland, Southern Rhodesia, and Northern Rhodesia.

Among diseases may be mentioned the leaf-curl, which has proved serious in the Sudan. The experiments in breeding resistant varieties have already been touched upon above. Blackarm was widespread and severe in parts of Uganda.

Studies upon bud shedding are being made in the Sudan, where it has been found that it was "the major factor in determining the low yields at Shambat . . . Most of the bud shedding takes place at a relatively early stage (bracteoles 0.8 mm. in diameter), and its effects are visible in diminished flowering about two weeks later. Excessively low humidities were probably largely accountable for the high rate of bud shedding."

In conclusion, attention may be drawn to the growth of the work at the Corporation's seed farm at Daudawa, where about 36,000 lb. of seed was secured and handed over to the Agricultural Department for distribution. Mention must also be made of the special difficulties with soil that are being experienced at Makwapala in Nyasaland; of the results of spinning tests and the brokers' reports carried out for Uganda, the Sudan and other countries; and the many other interesting features in which the reports abound.

CROP PRODUCTS MANUFACTURE.

Oils, Fats and Soaps.

The annual summary of progress in the oils, fats and soap industries is contributed to *The Industrial Chemist* by Mr. Rex Furness, M.Sc. (p. 22, Vol. VI). He emphasises that more attention is being given to the cultivation of plants having oil-bearing nuts and seeds. The extent to which hereditary factors and fertilisers can affect the yield and quality of the crude oil are being fully investigated. Fresh fields for growing oil-bearing plants are being sought and new species of oil-bearing plants investigated. Attempts, which appear to be successful, are being made to introduce the soya bean into England. The work of acclimatisation is still in the experimental stage, but there are indications that the soya bean may ultimately become a considerable crop in English agriculture.

The possibilities of producing tung oil within the Empire have been fully considered. The experience in America, where the production of a good quality oil is increasing rapidly, is encouraging. Growing experiments started in Africa and the East, have met with some success and it is possible that in a short time the difficulties encountered will be eliminated.

The imports of oils and oil seed into England during the year amount to practically the same as in the previous year. The only substantial increase has been in the imports of copra. There are indications that the amount of oil seed crushed in England rather than abroad is increasing.

Further important researches into the composition and distribution of glycerides in natural fats have been conducted at Liverpool under Professor Hilditch. From numerous studies of oils it is apparent that there is an even distribution of fatty acids throughout the glycerides. The results obtained will have far reaching influences on oil and fat technology and will probably be the means of introducing new methods of treatment and of enabling oils hitherto neglected to be utilised.

The margarine industry which is one of the chief consumers of natural oils is progressing steadily. Increased consumption may be due to the fact that the modern preparation is practically equivalent in dietetic value to best cows' butter. Vitamin D, prepared from irradiated ergosterol, is incorporated in the margarine. It is probable that Vitamin A will also be made and included, when the final product will differ only in a very slight degree from fresh butter.

The manufacture and sale of British soaps is still increasing. The chief advances have been made in the production of flake and powdered soaps. Such preparations should be rapidly and completely soluble, should not cake, and should flow easily from the containers. A preparation possessing all these properties consists of a powder compound of clearly visible, globular particles,

with hollow interiors. The wall strength is maintained, however, to prevent crushing during storage. Their value is limited by their relatively low density which necessitates large storage space. Powders of uniform particle size, thin, strong flakes, soap threads and shreds are also competing in the market.

Organic soaps, as distinct from the inorganic sodium or potassium soaps, made by combining two fatty acids with a commercial mixture of three ethanolamines have recently been introduced. The mono-, di-, and tri-ethanolamines are basic substances prepared simultaneously by the action of ammonia on ethylene glycol. The properties of the new soaps vary considerably with the nature of the fatty acid from which they are formed. Thus the oleate has a consistency of petroleum jelly, while the stearate is a wax-like substance. These soaps possess the valuable property, lacking in inorganic soaps, of being soluble in a great number of organic solvents. The solutions have good fibre penetrating properties and are excellent emulsifiers, grease solvents, and detergents. With this array of properties an important future may be predicted for these soaps.

The soap-lye glycerine industry is still in a precarious condition. Further improvements in the product of fermentation glycerine from molasses show that it will become a serious competitor in the near future. The most recent advance, apart from the spray distillation method, is the production of the alkali necessary for the fermentation process from the ashed residue of the spent molasses. The expense of the sodium carbonate used hitherto is thus removed. Ethyl alcohol is produced in sufficient quantity to pay for all the other raw materials used in the process. The cost of the glycerine is therefore only that incurred in distillation and purification. Whether the quality of fermentation glycerine can rival the high grade of the soap-lye glycerine is still to be proved.

Rubber.

Mr. S. A. Brazier, M.Sc., F.I.C., F.I.R.I., provides a summary of progress in the rubber industry during 1929. (*Ind. Chem.*, p. 30, Vol. VI.)

Recent figures show that both the consumption and the production of rubber during 1929 are greater than during the previous 12 months. Production is still in advance of consumption with the inevitable result that the price of rubber has dropped to the neighbourhood of eight pence per pound. British Malaya is producing 50 per cent. of the world's supply followed by the Dutch East Indies and Ceylon who are producing 31.7 and 9.0 per cent. respectively. Over 96 per cent. of the world's rubber supply is now produced by plantations. Of the remaining 3.6 per cent. about 3.0 per cent. is obtained from the wild rubber of South America. America is attempting to start plantations under her own control. With that end, she has obtained interests in Liberia and has imported large numbers of Guayule plants for the establishment of plantations in California.

Of the plantation rubber, only one-half is controlled by Europeans and the remainder by Asiatics. The majority of the Asiatic estates are negligently run, without regard for the future. Little attempt is made to cultivate the estates, to combat disease, or to conserve the bark of the tree. Disease may remove the bulk of these estates at any time. As comparatively low stocks of rubber are kept, the sudden removal of such large sources of supply would cause a serious inflation in the price of rubber.

Methods for increasing the yield of rubber per tree and consequently lowering the cost of production are being sought continuously. The two main lines of work are bud-grafting from high yielding trees, and the use of nitrogenous fertilisers. Both methods appear to be meeting with success.

The oil obtained from the seed of the rubber tree may become an important by-product of the industry. The oil possesses drying properties somewhat inferior to those of linseed oil. The residual seed cake may be used as cattle food.

Research in the production of various types of manufactured rubber articles is progressing. Carbon black from natural gas is still the main reinforcing ingredient, particularly where resistance to abrasion is required. New forms of carbon black and colloidal clays have also been incorporated with success. New accelerators and anti-oxidants have been placed on the market. Among the former is a delayed action type which will only become active at a temperature above that reached in the preliminary treatments. Any tendency to scorching or pre-vulcanisation is thus avoided. Ageing, vulcanisation and methods for physical testing have been studied and some advances made although no fundamental principles have been discovered.

The production of synthetic rubber seems to have made little advance.

New outlets for manufactured rubber are always being sought and developed. Rubber suitable for flooring, road material and footwear has been manufactured and used satisfactorily.

H. H. C.

RICE BORER PARASITES.

In Vol. XXXIV, No. 1, of the *Hawaiian Planters' Record*, Mr. F. C. Hadden, who in 1928 had been searching for parasites of the rice borer in Japan, Formosa and China, reports that 18 different species were found which more or less effectively controlled the pest in the Orient. Of this number of species ten were sent or brought to Honolulu where they arrived alive. They were then either turned loose in the rice fields or raised through several generations in the laboratory and then released. Three species of these parasites have been recovered in the fields and their establishment thus verified. They are: the egg parasite *Trichogramma japonicum* Ashm., and two larval parasites *Amyosoma chilonis* Vier., and *Dioctes chilonis* Cushm. It is possible that some of the other species of parasites have become established, but are still too scarce to be recovered.

TROPICAL WORLD NOTES.

Tanganyika.

The 1929 season was unfavourable for crop growth throughout the Territory owing to a deficiency in the rainfall which resulted in a general shortage of native food crops excepting in the Bukoba Province. In certain localities, it has been found necessary to distribute seed for the 1930 food crops.

The seasonal conditions were reflected in a marked reduction in production of the native cash-crops, particularly of cotton, groundnuts, coffee and copra. The estimate of the 1929 cotton crop, the ginning of which is not yet completed, is 3,500 bales below the 1928 production of 32,965 bales. The reduction in the export of coffee was from 10,431 tons in 1928 to 8,857 tons for 1929. The exports of groundnuts showed a reduction of 2,840 tons and that of copra 1,398 tons. The unfavourable season, however, had apparently little effect on the hardy sisal plant, which affords the premier export crop of the Territory, as production reached a total of 45,728 tons, representing an increase of 9,542 tons or 26 per cent. over the previous year; these figures, however, chiefly reflect the larger area of sisal which has come into production, as the continuing favourable prices for this fibre has led to much activity in establishing new plantations.

The sisal industry is wholly in the hands of estate agriculturists (as distinguished from native cultivators), the majority of whom are Europeans. Most of the coffee production of the Northern and Tanga Provinces, a large proportion of the copra production and about 25 per cent. of the cotton crop is also estate production. The trial cultivations by European planters of tobacco, coffee and tea in the south-western highlands of the Iringa Province were continued, but the extent of the development of these and other suitable crops in this region, which has a climate well suited to Europeans, will largely be dependent on cheaper transport facilities.

The export figures of the principal agricultural products of the Territory in the pre-war year 1913, and for the last two years are as follows :—

	1913		1928		1929	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Cwt.	£	Cwt.	£	Cwt.	£
Sisal fibre ..	416,680	535,580	723,720	1,111,429	914,560	1,485,593
Cotton ..	43,840	120,753	97,863	495,405	98,948	487,863
Groundnuts ..	179,220	95,932	211,900	188,582	155,100	120,448
Coffee	21,180	46,563	208,622	739,657	177,140	588,871
Copra	109,540	117,401	186,360	191,197	158,400	145,015
Simsim	29,520	20,407	64,300	61,342	85,120	74,773
Rice	15,420	8,717	79,973	85,884	51,884	58,885
Millet	18,210	5,498	154,636	52,243	95,323	30,334
Beeswax ..	11,180	70,743	9,815	71,079	6,721	48,149

—*By courtesy of the Department of Agriculture, Tanganyika.*

* * *

Montserrat.

The year 1929 proved a season of high rainfall and was free from any abnormal or atmospheric disturbances. The heavy rain experienced was responsible for the general restoration of the vegetation and agriculture of the island, so badly damaged by the disaster of 1928. Cotton was again the chief industry, 3,200 acres being planted. It has been estimated that close on 700,000 lb. lint should be realized. The general forecast of the cotton crop for the year in question at the time of reaping was none too favourable. Heavy rains causing a widespread outbreak of Bacterial Boll Disease was considered, at the time, a limiting factor to production. Owing to the almost complete absence of Pink Boll Worm, however, the late flowers of the season developed, and more than made up for the loss of early bolls affected by Bacterial Boll Disease. Small growers again enjoyed a highly competitive local market at 6*d.* per lb. seed cotton, or 1*s.* 10*d.* per lb. lint. It is interesting to note that approximately 200,000 lb. lint was purchased by an American firm of spinners for manufacture in the United States of America. The citrus crop made marked progress and climatic conditions were most conducive to rapid growth and development of young lime fields. Long wet spells with increased humidity were experienced, and an excellent start was made. It is estimated that 1,000 acres of young limes were planted out during the season. The planting of grapefruit, oranges and lemons was also continued. Exports of lime products were adversely influenced by the storm of 1928, but many young plantations are now coming into bearing. The production of tomatoes and of vegetables for the Canadian markets in the winter months is now being organised on a commercial scale with the help of the recently formed Peasants Information Office. Tomato shipments to the extent of 1,000 crates were made from the 1928-29 crop. The preparations and areas under this crop for 1929-30 show considerable increase. The shipping of the new crop started in December, 1929, and will extend to May, 1930.—(*By courtesy of the Curator, Department of Agriculture.*)

The Gambia.

Groundnuts form the staple export crop of the Gambia. They are grown on lands which have, in the main, been previously utilized for the growing of one or two food crops in succession. Good land will usually grow two food crops and then two groundnut crops in a four-yearly period. During the lengthy dry period, which extends from mid-November to early May, no agricultural operations are performed, as the rainfall is practically nil. Foodstuffs during this extended dry period, and before the first crops are harvested, not infrequently become scarce, especially if sufficient quantities have not been stored. If irrigation were possible crops could be grown in this dry period and a considerable improvement in the general economic condition of the people effected. Water lifts would seem to offer possibilities. The use of cattle for cultivation operations should also be experimented with and encouraged when rinderpest control measures are taken in hand, and investigations made of the possibility of growing short-lived food crops in groundnut cultivations, and of following the millet cereals with sesamum (benni seed) or pulse crops, which are capable of withstanding dry conditions. The cultivation of rice under irrigation is also worthy of investigation, as little extension of upland rice cultivation during the rainy period can be expected, as this is recognised by social customs to be the work of the women. Agricultural development in the Gambia is bound up with the question of manpower, and any extension is dependent upon increasing crops by means of selected seed types, by the introduction of animal traction for cultivation purposes, or by an extension of the cultivation periods by means of crops such as benni seed, lima beans, &c., or by the use of irrigation.—(*Report on West Africa* by F. A. Stockdale.)

* * *

Jamaica.

In his address to the Legislative Council of Jamaica, at the opening of the Session, the Governor mentioned that the year 1929 had been important since it had seen the inauguration of two enterprises: the shipping line of the Producers' Association and the new service to and from Canada. The first had brought the producer for the first time into close touch with the consumer in the Mother Country; the second had given Jamaica new and direct access to the great Dominion which was the natural market for the Colony's products.

These two enterprises, Sir Edward Stubbs stated, had been in operation for so short a period that it would be premature to speak yet of actual results, though it was worth while to mention the fact that in 1928 the direct exports of bananas to Canada were something over 57,000 stems, valued at £8,500, while in 1929 they amounted to over 2,250,000 stems, of the value of £321,000.

The Governor mentioned that during last year exports of bananas reached 22,000,000 stems—the highest on record. The value, £2,434,000, was also the highest yet reached. He stated that if climatic conditions were favourable, a crop of 25,000,000 stems of this fruit would be available for export this year. Panama disease was, however, spreading. This was the case last year. The only hope of continued prosperity, he said, lay in the possibility of keeping the disease in check until efforts to produce a banana that was both immune from the disease and suitable for export were successful.

The prospects of an enlarged trade in citrus fruits are distinctly good. Provision has been made in the estimates for a grant of £1,000 to the Jamaica Producers' Association to enable it to organize commodity associations to deal with various products; and also a grant of £5,000 to provide for the establishment of a central packing house. Sir Edward Stubbs informed the Council that £700 has been earmarked to assist silk production in the island. Reports which have been received from England show that silk of excellent quality can be produced and can become a valuable minor industry. The Empire Marketing Board offered £700 a year for two years, and £500 for a third year, provided the Legislature would vote equivalent sums.—(*The Times Trade and Engineering Supplement.*)

* * *

Madagascar.

Madagascar, a French Colony, situated to the south-east of Africa, from which it is distant, at the nearest point, about 240 miles. It has a length of 995 miles from north to south, and an average breadth of about 250 miles, although near the centre it is nearly 360 miles across. The area is about 228,000 square miles, or not quite four times the extent of England and Wales. Madagascar consists of an elevated mountainous region, from 3,000 to 5,000 feet in altitude, occupying from two-fifths to a half of the centre and the eastern side of the island. Around this there are extensive plains at a much lower elevation above the sea, which are most developed on the western and north-western sides. This lower region is broken up by masses of hills, with several elevated plateaux, especially in the south-west and south. The shores of the greater portion of the southern half of the island are low and flat, but in the northern half the coast is often bold and precipitous, the high land occasionally approaching the sea. There are some very elevated mountains extending to the south-eastern extremity of the island. The interior highland comprises nearly half the total area of the island. The lower region is fertile and well-wooded, especially on the eastern side of the island, although a large district in the south is barren. Nearly all round the island are dense forest belts. The flora of Madagascar is very rich and fertile and the island contains large numbers of valuable timber-producing trees. The soil of the coastal plains, especially on the eastern side, is fertile and suitable for growing almost all kinds of tropical produce. The principal exports are rubber, hides, rafia, cattle, rice, wax, vanilla, gold and timber. Although within the tropics, the climate varies considerably with the elevation.—(*The Colonizer*, Vol. XXXV, No. 411.)

COTTON NOTES.

By E. J. Maskell and T. G. Mason.

Effect of sap on fermentation by some yeasts.

We have recently had occasion in connexion with our work on Transport in the Cotton Plant to determine the effect of small amounts of expressed sap on the rate of fermentation of dextrose by some yeasts. Concentrations of sap as low as 0.1 cc. per 150 cc. of culture media[1] may bring about a significant acceleration in the rate of fermentation. The sap was boiled and filtered before addition to the culture media. Rates of fermentation were measured by periodical weighing of the cultures and different cultures were compared on the basis of the time required to complete half the total fermentation possible. In this way we were able to determine that saps from different parts of the cotton plant may show well marked differences in capacity for activating fermentation. Thus fermentation by *S. ellipsoideus* and by a strain isolated from Fleischmann's yeast was promoted more vigorously by sap expressed from bark (cortex+phloem) near the apical region than by sap expressed from bark near the base of the main axis. To test whether this downward gradient was connected with movement of the active substances along the bark, we compared saps expressed from bark above and below a ring on the main axis with saps expressed from the bark of corresponding regions of normal plants. We found a marked increase in the activity of the sap above the ring, but an approximately equal increase in activity below the ring. This suggests that wounding causes a local production of the active substances and that downward movement, if it exists, is relatively unimportant. The existence of the local response, however, impairs the ringing method as a test of movement and it would be unsafe to conclude that the active substances are not longitudinally mobile in the bark.

We have also ascertained that *Nematospora coryli Pegl.*[2], one of the saccharomycetes that has been isolated from cotton bolls affected with Internal Boll Disease, can bring about the fermentation of dextrose, and that this fermentation is accelerated by small quantities of sap expressed from the young seed. The interest of these observations lies in the possibility that the pathogenicity of this group of organisms may depend in part on the high concentration of sugar in the young seed and in part on the presence of growth accessory substances akin to Bios.

(1) Water	2,000	grms.
Dextrose	240	do.
Ammonium chloride ..	4	do.
Sodium di-phosphate ..	2	do.
Calcium chloride	2	do.
Yeast ash	2	do.

(2) Ashby, S. F. and Nowell, W.—The fungi of stigmatomycosis. *Ann. of Botany*, XL, 157, 1926.

Alcoholic fermentation by Nematospora coryli Pegl.

[*Comment by S. F. Ashby, Mycologist, Imperial Bureau of Mycology.*]

Mason and Maskell's observation that *N. coryli*, one of the fungi of Internal Boll Disease of cotton and of Stigmatomycosis, ferments dextrose, is of considerable interest; all earlier investigators of its behaviour in pure culture had overlooked this fact. I have been able to confirm it using single cell isolations of a strain from South Africa in peptonised five to ten per cent. malt extract solution in which active multiplication and brisk fermentation occurred. Single cell isolations were again made from the fermenting cultures and yielded in all instances sporing vegetations on potato blocks and potato saccharose agar characteristic of *N. coryli*. Inoculations from a number of these re-isolations into malt extract solution again resulted in alcoholic fermentation. As Ashby and Nowell did not observe alcoholic fermentation in peptonised cane juice, using strains isolated in the West Indies, it is probable that these were unable to invert saccharose. A record of the ability of *N. coryli* to ferment the different sugars would be of interest. It is possible, also, that the closely related *N. gossypii* may be able to ferment certain sugars.

* * *

West Indian Cotton Notes.

Montserrat.

The cotton planting season began this year on 16th February, the area prepared for the crop being the largest on record. Germination of the crop has been excellent but the plants are suffering from want of rain.

Nevis.

The yield of cotton will be very much less than was expected on account of severe attacks of cotton worm. Frequent rains in the month of January and a sudden change to dry weather conditions during the month of February caused the shedding of a fairly large percentage of the younger bolls. The pink boll worm has not yet made its appearance but the cotton stainer is more plentiful this season than it has been for some time past.

St. Vincent.

Cotton is still being reaped but in decreasing quantities. Planters are generally satisfied that the alteration of the planting season has resulted in better yields and cleaner cotton although in the early stages the same attention was not given to the crops as was given to previous ones. Stainers are increasing rapidly in the northern part of the island and internal boll disease is common; in this and other parts, the crop is finished. Pink bollworm is conspicuous by its absence.—(*By courtesy of the Departments of Agriculture, March*, 1930.)

COCONUT RESEARCH IN MALAYA.

By A. Sharples,
Government Mycologist.

[*Reproduced from the "Malayan Agricultural Journal," Vol. XVIII, No. 2.*]

Up to the time of the formation of the Rubber Research Institute of Malaya, the main activities of most of the Research Divisions of the Malayan Department of Agriculture were necessarily confined to the investigation of rubber problems. Coconut investigations, however, formed a main line in the Divisions of Economic Botany and Entomology long before the inauguration of the Rubber Research Institute and since 1920 much work has been done on coconut research by the officers of these Divisions. When the rubber work of the Department was taken over by the Rubber Research Institute, other Divisions devoted more time to coconut problems, so that at the present time this crop is receiving a considerable amount of attention as regards research necessities.

In 1920, the Division of Economic Botany commenced taking individual yield records with a view to studying variation in individual palms. In 1922, an Experimental Coconut Plantation of 50 acres was started between Klang and Port Swettenham and planted up with seed nuts of known origin.

The study of variability in coconuts by the Division of Economic Botany up-to-date has shown that as regards fruiting qualities, the co-efficient of variation in the number of nuts produced per annum is as high as 34 per cent. of the mean production per palm under average estate conditions. The study of variation has also revealed the fact that 19 per cent. of the palms on the average estate are unprofitable. Fruiting characters of individual palms have been found to be definitely constant over a period of eight years and no doubt this constancy also exists as regards the oil content of copra from individual palms within the range of seasonal variation. Investigations on this point are already in hand by the Chemical Division.

The entomological work from 1920 onwards included investigations into the life history of the more important pests of coconut palms and the following special bulletins have been issued.

(1) The Two-coloured Coconut Beetle (*Plesispa reichei*).

(2) Red-Stripe Weevil of Coconut (*Rhynchophorus schach*).

Further considerable work on the Black Beetle (*Oryctes rhinoceros*) and the influence of the Greater Spike Moth (*Tirathaba rufivena*) on immature nut-fall has been undertaken.

The study of diseases of coconut palms was under investigation during the days of intensive rubber work but after 1926, this work was considerably accelerated. The work was mainly concentrated on the elucidation of the so-called "Bud-Rot" problem. In 1922, a paper was published in the *Annals of Botany* describing inoculation experiments which led to the conclusion that the problem had not been finally settled and that, as far as Malaya was concerned, the whole subject needed reinvestigation. Some of the more important results already obtained, however, may be summarised as follows :—

(1) No evidence has been found to support the suggestion that a form of epidemic Bud-Rot caused by parasitic organisms, exists in Malaya.

(2) That Lightning is of primary importance in the question of so-called Malayan Bud-Rot and probably of other affections.

(3) That *Marasmius palmivorus n.s.* plays a rôle of some importance in so-called Bud-Rot manifestations in Malaya.

In 1928, a report entitled Copra Manufacture, by H. C. Sampson, was received in which he reviewed the present Empire position with regard to quality of copra and the possibilities of improving the quality, with suggestions as to the relevant lines of research and the place where the work could best be undertaken. The report suggested *inter alia* that "Malaya seems to offer the best scope for carrying out this work for not only is copra becoming of increasing importance as an export from there, but the country probably has better facilities in the way of staff and equipment than is possessed by other colonies interested in this matter. It would be a much better country than Ceylon since the climatic conditions in the main coconut growing districts of that island much more closely resemble those of the West Coast of India where sun-drying is largely practised."

As the matter was of considerable (Imperial) importance economically, the Empire Marketing Board, after consultation, expressed their willingness to provide a contribution towards the cost of the Research, an offer which the local administration accepted. The more immediate work on copra research obviously demanded study from the chemical point of view, and arrangements for the special appointment of an Assistant Chemist for Copra Research were made on the initiative of the Empire Marketing Board. The appointment was filled, and this officer assumed duties in October, 1929.

The question of the appointment of a Copra Research Chemist was under discussion when the Director of Agriculture arrived in Malaya in 1929. The Director of Agriculture suggested the formation of a Departmental Copra Research Committee, with the object of correlating the various lines of work in progress, and making suggestions for its extension on properly co-ordinated lines, the Heads of Divisions to sit as members with the Government Mycologist as Chairman. This Committee held its first meeting on 14th April, 1929, and made a number of recommendations relative to the desirability of collecting information on the subject of Copra Manufacture in Ceylon and the marketing of copra in England. As a result, the Government on the recommendation of the Director of Agriculture approved :—

(*a*) of an officer being deputed to obtain information as to the market standards required by copra dealers in England and data concerning

other factors influencing the price of copra on the English markets. A report on this subject has been lately submitted by the officer in question (Mr. D. H. Grist, Agricultural Economist).

(*b*) of an officer being deputed to visit Ceylon with a view to obtaining information relative to manufacture of copra in Ceylon, for purposes of comparative study. Subsequently, a schedule was submitted by the Committee to the Director of Agriculture indicating various additional lines of work which appeared to offer prospects of yielding useful information.

A considerable amount of useful research work on copra has already been achieved by the Chemical Division. This work comprised particularly :—

(*a*) Analytical comparison of the composition of Malayan copra with Ceylon and Malabar copra.

(*b*) Studies of variations in oil content of copra from selected palms. This work was being carried on in collaboration with the Economic Botanist.

With reference to (*a*) the work so far performed appears to indicate that commercial Malayan copra is of lower oil content than copra from Ceylon and Malabar, but this result required confirmation by further analyses. In the opinion of the Acting Agricultural Chemist, the alleged inferiority of Malayan copra may be largely due to climatic causes. Efforts will, therefore, be made to obtain further information on this point by importing seed nuts from Ceylon and Malabar, and by making enquiries in this country to ascertain whether any seed nuts have ever been imported from Ceylon, in addition to those at Klang Experimental Station, the trees from which are not yet in bearing. As a result, a provisional outline programme of work on copra research was formulated as follows. This programme may be subject to modification as experience is gained.

(*a*) The Assistant Chemist for Copra Research on arrival in Malaya should in the first place undertake a series of tours through the Malayan coconut districts with the object of obtaining a general knowledge of the various conditions associated with the coconut industry. These have already been commenced.

(*b*) After the preliminary survey, a detailed study of the production of copra stage by stage would be commenced. The following items indicate the more important lines to be followed :—

1. Systematic comparative analysis of native and estate copra from different districts in Malaya, Borneo and Sarawak.

2. Examination of further samples of copra from other countries, *e.g.*, Ceylon and Malabar and a detailed comparison of actual nuts from Ceylon, Malabar and Malaya—also microscopic comparison.

3. Laboratory experiments on the colour of soap produced, and the bleaching properties of coconut oil derived from copra from different sources—these tests are used in the soap and edible oil industry for grading oils.

4. Structural examination, radially and tangentially, of nuts of various shapes, sizes and states of ripeness in order to determine the best sampling position to be adopted in the succeeding work.

5. An elaborated examination including tangentially sectioning of under-ripe, ripe and over-ripe nuts derived from two high yielding and two low yielding palms.

6. The same from a palm yielding uniformly small nuts, and one yielding uniformly large nuts.

7. The same from palms of different ages, and also of different types—in conjunction with chemical analysis of soils and fruits.

8. Thinning out the flowers or young fruit to note the effect on the yield and oil per cent. of copra.

9. A study of tapping for toddy, noting its effects on yield and oil per cent. of copra.

10. An elaborated study of the structure and growth of coconuts obtained by dating individual nuts, immediately the spathe opens, and by picking individual nuts daily between 200 days and until natural nut fall commences, including microscopic examination and f.f.a. (*i.e.*, free fatty acid) determination.

The basis of comparison between the individual nuts will be the "ripeness factor" or "total oil per unit area of meat" (Oil per cent. Wet x Thickness of Meat x Sp. Gr. Meat) which will, it is anticipated effectively overcome individual differences in shape, size, meat, thickness and erratic development of the nuts examined. In this connection, neither total oil nor oil percentage (dry) is considered here an effective method for studying nut development.

11. Bulk determination of the total oil derived from 100 ripe ungerminated nuts and 100 partially germinated nuts and 100 young nuts, and the same for nuts kept one, two and four months longer before opening.

12. The preparation of a comparative statement of the picking systems in vogue on different plantations and the copra obtained (quality copra and oil yield per 1,000 nuts).

13. An examination of the working costs of different methods of collection and estate transport and the effect, if any, on the copra obtained.

14. The preparation of a comparative statement of the Capital Cost, Maintenance and Repair Charges, Life of Plant, Labour Costs, Capacity, Speed and Efficiency of existing driers and of the proprietary driers at present on the market.

15. A comparison of the working temperature and humidity conditions; and of the colour, structure and quality of the copra obtained by the existing methods :—Sun-drying, smoke-drying, simple hot air drying, and chula drying and also of perfect copra obtained on a small scale under laboratory conditions.

16. The effect of washing the meat in water, two per cent. formaldehyde, hypochlorite or sulphurous acid before drying.

17. The effect of "sulphuring" during drying.

18. The effect of the size of coconut meat on the rate of drying, and subsequent mould formation.

19. Small-scale experiments in burning coconut shell, using forced draught—consideration of the use of a gas producer as a source of heat.

20. Small-scale laboratory experiments under varying conditions of drying, noting structure and physical condition of resulting copra.

21. The effect on mould formation, of chopping the copra after drying.

22. A study of the storage of the different types of copra from different sources under warehouse conditions, noting variation in oil, f.f.a. and moisture.

23. A study of the maintenance of low moisture content, or its fluctuation under conditions of varying humidity for copra of different physical structure.

24. A study of mould, f.f.a. formation and insect attack under varied conditions of temperature and humidity.

25. A comparison of clean and mouldy copra from the same source.

26. The effect of mixing (on a 25 per cent. 50 per cent. and 75 per cent. basis) of estate with native copra, noting results.

27. A study of the temperature and humidity conditions in a copra cargo boat with a view to possible improvements.

28. The actual preparation on a large scale of copra containing 72 per cent. oil and a comparison between it and that derived from Ceylon and Malabar, and the working oil and copra yield per 1,000 nuts.

In addition to the above, a considerable programme of research work on coconuts is in hand in the various Divisions of the Department. The following may be mentioned :—

(*a*) The selection and breeding of improved strains of coconuts.
(*b*) Manurial and cultivation experiments.
(*c*) Pests and diseases of coconuts.
(*d*) Catch crops and cover crops in coconut cultivation.

The preliminary work on the structure of the coconut fruit has been started and although only a few months have been spent on the work, important subsidiary indications have been obtained.

Variation in oil content has been studied in (*a*) for different nuts and (*b*) for different parts of the same nut.

The results for (*a*) show that a considerable variation exists in oil percentage (D.B. = dry basis) in pieces of meat derived from nuts normally picked on Malayan estates as shewn by a range from 45 per cent. to 75 per cent. The copra resulting, from which the individual pieces were picked, will probably show the same variation; this indicates that there is considerable room for improvement if a more uniform product with a higher average oil content can be produced.

The results for (*b*) show considerable difference in oil percentages in pieces of meat from different parts of the same nut, most particularly in nuts not fully ripe. This throws considerable doubt on the utility of any nut sampling which has been done in previous experimental work when the state of ripeness has not yet been specified and when the sampling has been done at random.

Experiments in the selection of the best sampling position have shown it is desirable to take samples near the middle of the nut and not from the ends where extreme differences are found. Further, when tangential slices are examined, an oil gradient has been determined, with the lowest oil percentage on the inside face of the meat gradually increasing in value as slices are taken nearer the shell. In these preliminary experiments, the difference in oil percentage of a one-tenth inch slice of meat from the inside face as against a similar piece nearest the shell seems to show a fairly constant difference of 38 per cent. to 40 per cent. This applies only for a ripe ungerminated nut; the meat from nuts containing a germinating embryo does not show this oil gradient.

The effect of ripeness on oil yield has been studied extensively and the results show that there is an increase in oil percentage as the nuts germinate and become over-ripe. In the samples examined, an average increase in oil percentage was found, from 63 per cent. when the nuts were considered to be ripe, up to 72 per cent. when the nuts held a germinating embryo three and a half inches in diameter. This result confirms the studies made by analysing tangential and radial slices of meat. This finding may have some significance in the question of the apparent superiority of Malabar and Ceylon as compared with Straits copra, if it is correct that, in Malabar, the nuts are allowed to fall naturally, while in Ceylon there is a longer ripening period and the nuts are kept for a considerable period after plucking. The question of whether the total oil in the nut continues to increase after the nut is considered to be ripe has still to be determined, but it appears that the best plucking age will be an important economic factor, if copra should ever be valued according to oil content.

Further work on copra deterioration has been done and it has been shown that badly deteriorated samples of native manufactured copra may show the remarkably high average oil content of 67.2 per cent. which is two per cent. in excess of the average for large good quality samples of Malayan estate copra.

During deterioration it may be accepted that the total oil content is diminished owing to the degradation of the actual oil containing meat, which will result in a net loss in weight of copra, by agencies such as moulds, insects and heat. But it is a fact that such copra when analysed may show a high oil percentage content with usually high development of f.f.a.

The preliminary experiments have provided very interesting results and confirmatory and extensional experiments are being carried out.

A comprehensive scheme of research work on coconuts has been proposed in Ceylon, and a special research station for this crop is being organised in that country. Copra research work is also being undertaken at the Biological Station,

Slough, attached to the Imperial College of Science and Technology, London, and discussions are in progress with a view to establishing co-operation between Malaya and these stations. Every effort will be made to maintain touch with all research stations undertaking coconut research work, as lack of such co-operative effort often leads to unnecessary duplication of effort.

It is proposed that a half-yearly report on the progress of the copra research work will be published and so soon as sufficient experience has been obtained and the work of the Copra Research Chemist has become established along sound lines, definite proposals for the erection of one or more experimental driers will be put forward. The results of completed pieces of research will be published as bulletins of the Department of Agriculture, while summaries thereof will appear from time to time in the Malayan Agricultural Journal.

IODINE IN ANIMAL NUTRITION.

[*The following is a summary of an article on "Iodine in animal nutrition" by J. Park Hamilton which appeared in the Rhodesia Agricultural Journal, Vol. XXVI, No. 9.*]

One of the most important mineral elements necessary for the proper functioning of the internal secreting glands (*e.g.*, thyroid) is iodine. A marked deficiency of this mineral in the diet has been found in animals to result in unthriftiness, lack of growth and rickets. A sufficient deficiency may, on the other hand, only mitigate against the animal attaining normal development. Practically throughout the world, experiments in recent years have indicated that in many areas there is an iodine deficiency and that a general improvement has resulted with the addition of small quantities of iodine to the diet.

The usual way to administer iodine is in the form of potassium iodide, which, in addition to being readily absorbed, is odourless and practically tasteless. It can be given to cattle, pigs, sheep and poultry.

With cattle: young stock, pregnant cows and dairy cows are most likely to benefit from iodine which may be added to a salt lick in the proportion of 3 ounces of potassium iodide to each 100 lb. of salt. The iodide should be dissolved in a quart of water and sprinkled evenly over the salt. The iodide can also be incorporated in a mineral mixture in the following proportions:—

Bone meal or bone flour ..	40 lb.
Ground lime (slaked).. ..	40 lb.
Salt	25 lb.
Potassium iodide	3 oz.

The potassium iodide should be dissolved in a bottle of water and sprinkled over salt and when dry, thoroughly mixed with other ingredients. Such a mineral mixture should be added to the concentrated food in the proportion of 2 to 3 lb. to each 100 lb. of food. The mineral mixture may also be given in the form of doses varying from a teaspoonful to calves to a tablespoonful for mature cattle, given in the daily food.

For pigs the following mixture is recommended:

Bone meal or bone flour ..	25 lb.
Ground lime (slaked).. ..	25 lb.
Salt	15 lb.
Wood ash	15 lb.
Sulphur	5 lb.
Iodide of potassium	3 ozs.

The iodide is dissolved as previously and given at the rata of 2 lb. to each 100 lb. of food.

G. G

PATCHOULI OIL.

The tiue patchouli oil is derived from *Pogostemon Patchouli* (var. *suavis*), H.K.f., which is cultivated in Malaya. It is obtained chiefly from Singapore and Penang, also from Java, Sumatra and the Seychelles Islands. Various leaves with a patchouli-like odour are also used, the Javan *P. Heyneanus*, Benth., cultivated in India, and growing wild in the neighbouring countries, is now largely replaced by the true. The Chinese, *Microtaena cymosa*, Prain, sometimes offered as the genuine, occurs in Assam, Burma and Siam; and the leaves of *Urena lobata* L., and *Hyptis suaveolens*, L. are much used as adulterants. The plant was previously identified as *Mentha Cablin* by Blanco, and as *P. Cablin* by Benth., from the native name in the Philippine Islands of Cablam. It is also known as "Dilem" in Malaya, and in other parts as Tilam Wangi and Dhalum Wangi. The leaves of the plant, it is believed, were used in China in the very earliest times, and afterwards by the Indians or Hindus, the Egyptians and other ancients, for the perfuming of incense, shawls, and other wearing and covering material. The leaves first appeared in the United Kingdom *via* New York from China in 1844.

The oil is obtained from the sun-dried leaves which are sometimes allowed to ferment slightly. They are collected at centres and exported to Singapore, Java and Europe for distillation, usually by direct steam. In Johore under varying unknown conditions the production is in four grades known as "ordinary," "medium," "special" and "extra special" oil. The yield from the selected leaves is from 3 to 4 per cent., but the addition of leaf-stalks gives inferior oils and much less yield. De Jong, 1906-9, estimated the yield as two to three times greater from the dried and fermented leaves than from the fresh green, the odour in some instances differing greatly. The ordinary and medium Johore oils appear to agree with the Singapore, the "special" and "extra special" closely resemble European distillates. The commercial leaves largely come from Sumatra, with a little from Singapore and Johore. They are at times adulterated with the residual leaves from distillation, and this is detected by a small yield. The French and English oils are very fine; they are more expensive but are much stronger oils especially useful for fine perfumery. The Singapore oils are suitable for ordinary working and the Java in general for soap perfuming.—(*Perfumery and Essential Oil Record*, Vol. XX, No. 10.)

MYCOLOGICAL NOTES.

The Sclerotium Disease of Coffee.

According to a paper by E. B. Martyn which appeared in Vol. III, No. 1 of the *Agricultural Journal of British Guiana*, S. *coffeicolum* is said to be a species of Sclerotium, living normally as a saprophyte upon decayed vegetable matter, which is able under certain circumstances to attack the tissues of living plants. To enable it to do this extensively, however, it is necessary for the motile organs of the fungus to be produced, namely the peculiar rigid bristles, but conditions suited to the formation of these are limited, and apparently in the natural environment of the fungus, are seldom attained.

It is of interest to compare S. *coffeicolum* with S. *rolfsii*, of which Nakata, in his studies on the latter fungus, regarded it as a strain. S. *coffeicolum* differs from S. *rolfsii* in the fact that it is a weaker parasite, and attacks the aerial portions of plants and not the root and base of the stem. Its comparatively wide range of hosts is a point in common with he other fungus, although conditions suitable for its attack are less generalised. By a combination of suitable circumstances, this species of *Sclerotium* has established itself upon Liberian coffee in certain localities, and finds in this plant, as grown under cultivation, a well adapted host. But normally, at only one season of the year, do conditions occur suited both to the production of bristles and the further development of the fungus. When the conditions are especially favourable, the fungus may spread on the coffee to an alarming extent. These major outbreaks, however, are apparently of irregular occurrence, the damage done by the fungus in normal years being comparatively slight. Martyn summarises his investigations as follows: (1) Sclerotia and rhizomorphs of S. *coffeicolum*, similar to those found on debris beneath coffee bushes, were discovered upon dead leaves in the neighbouring forests in the North-west District, and also elsewhere. (2) The unmistakable bristles of the fungus were seen on the leaves of a number of plants other than coffee in the North-west District, and in one case were found upon a wild plant in another part of the Colony. (3) Similarity of appearance both in nature and in artificial culture, together with results of inoculation experiments, showed the fungus found on dead leaves in the forests to be identical with that causing the disease of coffee bushes. (4) Observations point to the fungus being a fairly common saprophyte, which is able under suitable circumstances to attack living plants, the essential factor in this attack being the formation of the bristles.

It is suggested that the optimum conditions for the periodic outbreaks of the disease only arise in the dry spell following the long wet season, a certain minimum of humidity, however, being necessary for the development of the fungus. Control measures should primarily be aimed at avoiding, as far as possible, conditions which favour the development of the fungus, and attention is particularly directed to better cultural operations. Spraying experiments have been designed of which results are, however, not yet available.

* * *

Variations in the percentage of Cacao Crop lost through Pod Diseases.

Data has been collected on the loss due to Pod Diseases of Amelonado cacao (chiefly *Phytophthora palmivora*) in the Gold Coast. The figures analysed extend over the period from April, 1926 to December, 1928, and were recorded at Kpeve, where the plantations are situated in a sheltered valley on a fairly deep medium clay soil overlaid by a layer of rich humus. The highest percentage of infected pods (79.43) was found among those collected in May, 1926, and the lowest (3.39) in the lot of August, 1927. There is no apparent correlation between these data and any general seasonal features. The numerical extent of infection was found to be no criterion of the amount of damage in terms of useless pods. In July, 1926, and January, 1927, when about 50 per cent. of the pods were diseased, only 9.14 and 16.27 per cent. were sufficiently bad to be rejected. On the other hand, in August, 1927, and March, 1928, when the infected pods only amounted to 3.39 and 11.18 per cent. of the collections, 84.39 and 99.66 per cent., respectively, were useless. The average annual loss of potential crop (derived by adding to the actual dry cacao obtained in any one month the *pro rata* value of the useless pods and then extracting the percentage of the possible crop with the useless pods present) was estimated at 13, 6.51 and 6.86 per cent. in 1926, 1927 and 1928, respectively. (*The Rev. of Applied Mycology*, Vol. IX, Part 3.)

* * *

The Non-Toxicity of the Secretions of Phytophthora faberi Maubl.

In black pod disease and cushion canker of cacao (*Phytophthora faberi*) large areas of discoloured and necrotic tissue are found in which hyphae cannot be detected. This may be due either to the disappearance of the fungus from the injured tissues through exhaustion of nutritive material or auto-intoxication, or to the toxic action of the fungous secretions on tissues which have not actually been invaded. In an experiment conducted to determine whether the substances secreted by *P. palmivora* are toxic to cacao tissues, pods were inoculated with filtrate of the fungus from Dox's fluid medium and dilute cornmeal infusion, a syringe being charged with the filtrate and a needle plunged through the cortex and sclerenchymatous layer into the placental cavity. While withdrawing the needle the inoculum was forced from the syringe and thus brought into contact with the placental mucilaginous tissue, and the vascular and cortical tissues. No discoloration developed in these tissues, and it is therefore concluded that *P. palmivora* does not secrete substances toxic to cacao pods.—(*The Review of Applied Mycology*, Vol. IX, Part 3.)

SUGAR IN 1929.

PRICES at the beginning of 1929 were at such low levels that it seemed unlikely that a further prolonged decline would continue, say Messrs. Wessels, Kulenkampff and Company. In January, prices for the spot month ranged from 1.99 to 2.05. A fair recovery occurred in February-March, due to scarcity of supplies and greater interest by refiners. The general trade and operators were also buyers in view of a prospective tariff increase before Congress, and under these influences prices advanced to 2.26. As it became evident that Cuban production would exceed 5.1 million tons, offerings were free, and prices again began to decline. May liquidation brought prices down to 1.65 by 11th June. July futures were selling at 1.59. Renewed tariff activity caused a complete change in the sentiment, and a sharp recovery followed, aided by rumours of the establishment of a Single Seller in Cuba. This organisation was finally authorised by a decree of 26th July. Strong interests, including a Cuban Consortum, took delivery of over 20,000 tons in tenders during September liquidation, as a consequence of which prices advanced to 2.31 for September and 2.35 for December, the highest prices of the year. With further postponement of the tariff issue at Washington, prices from this point declined gradually, and under December liquidation went down to 1.83. The Cuban market Single Seller Agency has maintained a firm attitude, and was able to dispose of the larger part of the 400,000 tons of old crop under its control at full prices.

The raw sugar market followed the trend of the futures market. The lowest price for spot sugar was recorded on 11th June at 1.6875c. c. and f. equal to 3.46c. duty paid. In the subsequent recovery raw sugar sold up to 2.3125c., or 4.08c. duty paid, at various times during July-October. Subsequently, offers of Cuban sugars not under the control of the Single Seller and duty free brought prices down again in November to 3.71c. duty paid, equal to 1,937.5c. c. and f. On 31st December last, sales were made 3.80 to 3.83 for duty-free sugar, parity of $2\frac{1}{32}$ to $2\frac{1}{16}$c. c. and f. New York.

Consumption in the United States rose from 5,542,636 tons refined value in 1928 to a record level of 5,810,980 tons in 1929. World consumption, in thousands of tons raw value was estimated at 26,259 in 1928-29, against 25,548 in the previous year.

The total was composed of: United States, 6,113; Europe 7,053 and non-statistical countries, 13,093. Exports of refined sugar, including candy, were 1,693,032 tons in 1927; 1,495,338 in 1928; and 3,333,144 tons valued at £2,745,719 in 1929.—(*The Economist, Commercial History of* 1929, Vol. CX, No. 4, 512.)

COPIES of *Insect Pests of the Lesser Antilles*, by H. A. Ballou, price *2s. 6d.* can be purchased on application to the Editor, *Tropical Agriculture.*

ENTOMOLOGICAL NOTES.

Compiled by the College Department of Entomology.

Natural Control.

IN the *Review of Applied Entomology* (Vol. XVIII, Ser. A. Part 2), a paper on "Natural Control" by Mr. W. R. Thompson, which appeared in *Parasitology*, XXI, No. 3, is summarised as follows: The author defines natural control as the check exerted on the multiplication of organisms by natural, as opposed to artificial, environmental factors. He considers that the idea that the distribution of an organism is chiefly determined by one or two limiting factors is incorrect. The reduction of reproductive rate preventing an increase or determining a decrease in numbers is due in the vast majority of cases to complex combinations of factors, of which different members predominate in different times and places. That the natural control of organisms can be effected by agencies of different kinds depends on the fact that it is primarily due, not to any complex universal mechanisms or regulatory factors, but rather to the intrinsic limitations of the organisms themselves. Every organism has certain specific characteristics, and an environment that meets its specific needs is, for a given species, the optimum environment. Given this environment, indefinite increase at a specific rate is possible; but the environmental conditions are in no two places exactly alike, and at a given moment, in a given moment, in a given area, the precise environmental complex constituting the optimum for a given species will be found at relatively few points. When conditions approach the optimum, the species automatically increases in numbers. This increase constitutes what is called, technically, an outbreak, which is of necessity an abnormal phenomenon. The organism, however, obviously cannot go on increasing indefinitely. As it increases in numbers, it necessarily spreads, both in space and time. As it spreads, it moves to points outside its optimum environment, when its rate of multiplication immediately diminishes. Thus, even under most favourable conditions, there cannot be a continuous and uninterrupted increase in numbers, but simply an oscillating movement, which is more likely to be feeble than extensive, because of the narrowly circumscribed optimum and restrictive adaptive powers of the majority of species.

The author believes that the control of insect pests is principally effected by physico-chemical factors, rather than by entomophagous insects. The reason for this is that parasitic control is effected by their specific organisms, whose distribution in time and space is limited by their specific requirements, of which the presence of the host is only one. Only a few of such organisms are capable of acting upon any given host. The physical factors of control, on the contrary, are simply intensities of omnipresent physical and chemical influences above or below the limits between which a given species can subsist. The range over which they will be

found acting is obviously far more extensive than that of the biotic factors. Furthermore, the number of physical factors of control is, for practical purposes, unlimited, since any departure in either the positive or negative direction of any physical factor, from the intensity that a given species can tolerate, will eliminate it. In general, it appears that such tropical regions as are favourable to life in general will be those in which the biological factors will be of the greatest importance as compared with physical ones, and that in regions unfavourable to life in general they will be relatively unimportant. The part played by biological and physical factors respectively, in the control of any organism in a region, can, however, be determined only by careful investigation, since these general rules are not always applicable. The most promising method for attacking the problem of the natural control of a given species is to determine the ecological optimum, by a careful laboratory study of its physiology and habits. The organism with its specific behaviour and requirements is the centre of the problem, and it is not until this is understood that a clue will be found to the fluctuations in its numbers.

* * *

History and Activity of Locusts in Kenya and relative Costs of Destruction.

Invasions of locusts (*Schistocerca gregaria*, Forsk) have been recorded in Kenya Colony in 1892, 1894 and 1898. From 1901 to 1909 and 1914 to 1917 locust swarms came every year; they were recorded in 1919, but were not observed again until March, 1928, when the present invasion started. Three-quarters of the land surface of the Colony, which are scarcely populated, are ideal places for locust propagation, and control measures are bound to be expensive and incomplete until the territory is further developed. For the time being most of the uninhabited areas can be reached only by aeroplanes; it is hoped that it may eventually become possible to use these to scout and drop poison bait or sodium arsenite dust.

It is maintained, however, that relatively inexpensive measures of destruction should be used wherever possible. As the result of experience obtained during the present invasion, a scheme of locust control organisation was suggested, with central headquarters situated in Nairobi and district field headquarters with eight operating units, each consisting of a temporary locust officer and native staff. A detailed estimate for such an organisation would show the total cost of the upkeep of one field headquarters and units during 40 days, which are necessary to exterminate an infestation of five to six thousand acres of actual hoppers, to be about £3,800.

Against the flying swarms, flame-throwers, sprays, dusts, and baits may be used, but the results obtained do not usually justify the cost. Against hoppers, baits and contact spraying or dusting with sodium arsenite are suggested. For spraying, five ounces sodium arsenite is dissolved in four gallons water; the cost is about 19s. an acre with hand pumps, and 6s. with a pump used direct from a lorry. Dusts should be applied with tins converted into fine dredges. Bran, dung, chopped potato tops, sisal waste or chenopodiaceous weeds can be used for the baits, with or without an admixture of ten per cent. of fresh crushed hoppers. Sodium arsenite is added at the rate of 20 ounces to 100 pounds dry bait, with as much water as is necessary to damp the bait evenly. Fairly moist bait is flung out among aggregates of hoppers in the evenings and mornings; during the day this should be done only when they are feeding. Egg destruction may be effected by hoeing over the infested land.—(*The Review of Applied Entomology*, Ser. A. Vol. XVIII, Part 2.)

* * *

Infestation of Stored Products.

The Empire Marketing Board has appointed a Committee to advise on the "Infestation of Stored Products by Insects and Fungi," of which the membership is as follows: Mr. E. M. H. Lloyd (*Chairman*), Mr. H. Brown, Dr. E. J. Butler, Dr. P. A. Buxton, Mr. J. C. F. Fryer, Mr. F. Laing, Mr. T. W. Macara, Dr. J. W. Munro, Dr. J. G. Myers, Mr. H. C. Sampson, Prof. V. H. Blackman, Mr. W. S. Thomson (*Secretary*). By a series of grants made to the Imperial College of Science and Technology, the Board has enabled the College to establish at Slough a station for the conduct of research on the infestation of stored products. This work is under the direction of Dr. J. W. Munro, assistant professor of entomology in the college, and has been planned along lines similar to those laid down in the Tenth Report of the Royal Society (War) Committee on Grain Pests for the continuance of the work on grain pests which it had begun, but which terminated shortly after the conclusion of the War. Thus, the work is considered as comprising three main activities: survey or intelligence work, biological and mycological research, and the application of research results to the control of insects and moulds. The survey or intelligence work is carried out mainly at the London docks, with occasional work at Bristol and Liverpool. The biological and chemical research work is carried out at the Biological Field Station at Slough, but the application of results to practice has not yet been carried out except on a small scale, because, as is obvious, successful application requires fuller knowledge than can be obtained in the short space of time during which work has been in progress. For the present, the research in progress is concentrated on cacao, copra, and dried fruits, but other products are also receiving attention, and the whole field of stored products in entomology and mycology will be explored as time and opportunity permit. — (*Nature*, Vol. CXXV, No. 3141.)

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Affining Sugar by High Speed Centrifugal.

J. Berge, General Director of the Belgian Sugar Factory at Tirlemont, has been granted an Austrian patent, the principal claim of which reads as follows: Process for desugaring run-off syrups, characterized in that the syrup to be desugared is distributed in a thin layer over pure sugar crystals, whereby as a result of cooling or evaporation a supersaturation of the syrup is brought about, and a part of the sugar in it crystallizes out. A sub-claim under the main claim reads: Form of execution of the invention according to claim 1, characterized in that the product so obtained is centrifuged in a centrifugal machine, the centrifugal force of which exceeds that commonly employed, and a part of the sugar crystals obtained is used for a subsequent operation.

The patent is intended to cover a process which amounts to an interesting modification of the usual process of affination in a sugar refinery. The raw sugar which contains a variable amount of adhering molasses, is to be subjected to the action of centrifugal machines revolving at very high speeds by which a considerable proportion of the impure molasses is thrown out, thus simplifying and abbreviating subsequent refinery operations.

With the permission of the patentee the authors (officials of the Prague Sugar Research Station) made an experimental investigation of the process described in the patent. They constructed a centrifugal machine having an effective radius of 32 centimetres (about 13 inches) which could be revolved at 2,500 r.p.m. giving a centrifugal force of 2,180 times gravity which is about three times greater than usual. Two raw beet sugars were experimented with. The results are given in the table below, in which columns A and B give the composition of the original raw sugars; column C the composition of sugar A after ten minutes spinning; column D the composition of A after an addition of 2.1 per cent. of water and spinning ten minutes; column E the composition of sugar B after spinning 30 minutes.

	A.	B.	C.	D.	E.
Pol.	96·1	95·8	98·3	99·1	98·8
Ash	0·80	1·01	0·43	0·28	0·42
Water	1·57	1·82	0·57	0·50	0·65
Yield	92·1	90·7	96·2	97·7	96·7
Org. Non-Sugar	1·53	1·38	0·70	0·12	0·13
Quotient	97·8	97·5	98·8	99·5	99·0

The figures indicate a perceptible improvement in the quality of the sugar, which will be recognised in the decrease of ash content from 0.80 per cent. to 0.43 per cent. in the first experiment with sugar A, and to 0.28 per cent. in the second experiment with the same sugar after the addition of a trifling amount of water (2.1 per cent.), the yield rising in the latter case from 92.1 to 97.7. However, the greater amount of water in this case resulted in a molasses of 63.8 purity. It appears that under this great gravitational force there is a differential separation of the impurities in the molasses, the heavier ash constituents tending to pass out while the colloidal organic non-sugars tend to be held by the sugar crystals.

This process is no complete affination in the accepted sense of the word, but it appears to be of interest in so far as it indicates a possibility of reducing the volume of liquids now involved in the usual refining process.—(*Facts About Sugar*, Vol. XXV, No. 15.)

* * *

The Measurement of Turbidity.

The measurement of turbidity in filtrates has long been a problem not only in sugar refineries but in chemical industry in general. Previous means of measuring turbidity have been vitiated in part by the concomitant unavoidable measurement of colour of the filtrate. A method here devised is based on the reflection of light from a Tyndall cone through a filtrate film approaching zero thickness. The turpidity of the solution is measured by observing the Tyndall cone, through a cone-free solution of potassium dichromate saturated at 20°C. The turbidity is designated as the number of centimetres of dichromate solution which obliterates the cone. On dilution of turbidities found in house sugar liquors with cone-free sugar solution, the turbidity is inversely proportional to the dilution until the extreme high dilutions are reached, when the turbidity drops off rapidly.—(*Facts About Sugar*, Vol. XXV, No. 15.)

* * *

Cane Plantings in Hawaii.

Statistics in Hawaii of cane plantings for the year 1929 show that H 109 occupies 39.56 per cent. of the total area under cane sugar, followed by D 1135 (16.09 per cent), Yellow Caledonia (15.47 per cent.) and P.O.J. 36 (12.53 per cent.). P.O.J. 36 has been the most spectacular performer during the last two years, the area under its cultivation increasing from 148 acres to 4,935 acres. The island of Kauai leads in P.O.J. 36 plantings, with Hawaii next. It is believed that this cane will spread on account of its many excellent qualities, among which may be included its high resistance to all the cane diseases in Hawaii, and rapid closing-in which makes it a good cane for weed control in the wet districts. Badila has almost doubled in area in the last two years.—(*Hawaii Sugar Planters' Association, Circular* 55.)

TRANSPORT IN THE TROPICS.

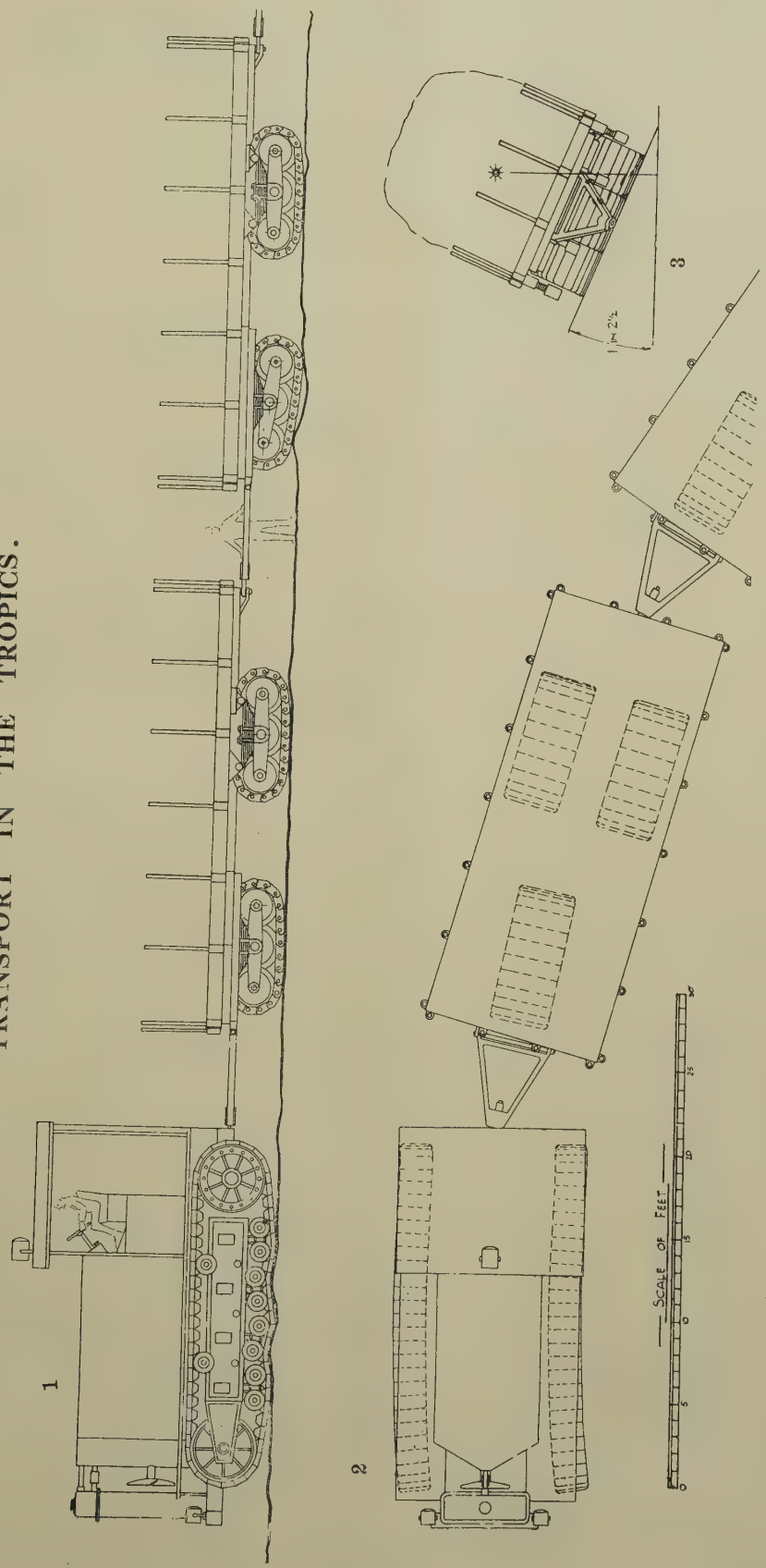

FIG 1.—*The* 100-*ton Roadless Train described in this issue.* FIG. 2.—*Plan view of the tractor and trailers whilst steering. The tracks being shown dotted.*

FIG. 3.—*End view of a trailer showing the angle of stability on a side slope.*

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CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Guayule Rubber.

An account of the propagation and cultivation of the Guayule shrub in the United States of America is given in *Industrial and Engineering Chemistry*, p. 385, Vol. XXII. North America has hitherto been dependent almost entirely on the far east for her rubber supplies. Production of rubber within the country is considered to be highly desirable. Since the usual rubber producing plants will not grow under North American conditions, attention has been turned to a shrub known as Guayule (*Parthenium argentatum*) which grows and produces a rubber-like material in the Mexican deserts. Experiments, started with a few seeds planted in 1912, have resulted in a plantation of 5,000 acres at the present day which is to be extended by 2,500 acres annually.

Initial germination difficulties were overcome by a chemical treatment of the seed. Germination was thereby increased from five per cent. to 96 per cent. The wild plants obtained from Mexico showed great variations. By careful selection with due regard to rubber content, hardiness, and ease of development, a high bearing, uniform strain which would withstand the new climatic environment was obtained, and has formed the basis of the present crops. Development of new strains is still progressing and it is hoped that plants of more rapid growth and a higher caoutchouc content will be obtained.

The seeds are sown in a nursery and the young plants planted out after 12 months by a mechanical planting machine. This machine is capable of planting 150,000 plants in eight hours. The regularity in planting so obtained, enables all weeding and hoeing to be done mechanically.

The young plants after one year's growth will yield 1,164 lb. of caoutchouc per acre representing a content of 6.3 per cent. on a defoliated, dry weight basis. Four years is considered the optimum period of growth though it is hoped to reduce this to two years, without affecting the yield of caoutchouc per plant.

Extraction of the rubber from the plant is performed by a continuous pulverising and disintegrating process. The product is well washed with water, the rubber coagulates, and the agglomerates or "worms" are separated from fibre and bagasse by flotation. The worms are cleaned, dried, and pressed into blocks. A recovery of 99.75 per cent. is obtained.

The chemical composition of the rubber appears to be identical with that of Hevea rubber, Vulcanisation can be performed in the usual way. The physical properties may differ somewhat from those of Hevea rubber but depend largely on the method of extraction. By an initial retting process similar to that used for flax, the acetone soluble materials of the rubber are reduced to about five per cent. and a product very similar to plantation rubber results. The cost of production should permit the Guayule rubber to compete successfully with imported rubber.

Soil Neutralising Values of Liming Materials.

An extensive investigation of the effect of various grades of limestone and basic slag on soil acidity has been performed by W. H. Pierre (*Soil Science*, Vol. XXIX, p. 137). The effects of the various materials were compared with the effect of precipitated calcium carbonate, which was taken as an ideal substance. It was found that the greater the initial acidity of the soil, the more rapidly did all grades of limestone re-act. The finer material was more efficient and more rapid in its action. Thus, the application of ground limestone which would not pass a 20 mesh sieve to a clay soil at the rate of seven tons of calcium carbonate per acre raised the pH value of the soil from 4.60 to 4.90 in 12 months. A similar application to the same soil of limestone ground so that it would all pass a hundred mesh sieve, gave an initial rise to pH 6.35 in one month followed by a steady decrease to pH 5.13 during the following 12 months. An application at the rate of nine tons per acre of precipitated calcium carbonate produced an initial rise to pH 7.10 followed by a decrease to pH 5.43 after 12 months. Parallel results were obtained with other types of soil.

The efficiency of ground oyster shells likewise depended on the fineness of grinding, and was equal to that of ground limestone in neutralising soil acidity. High grade basic slag produced nearly the same ultimate effect as the precipitated carbonate although its action was slower. Low grade basic slag had an indifferent effect.

The above conclusions were drawn from pot experiments conducted in a greenhouse.

* * *

A New Rubber-bearing Plant.

The Soviet Government is contemplating the exploitation of a new source of rubber. It has been known for centuries that plants of the order Chondrilla will exude a white latex which can be coagulated to form a rubber-like, elastic substance. Whether it is possible to find or breed out a variety capable of being utilised economically is to be investigated by the Russian Chemists. The yield of such a plant will have to be abundant and the quality of the final rubber excellent if it is to prove a serious rival to rubber at present prices.—(*Ind. Eng. Chem. News. Ed.*, Vol. VII, No. 4.)

* * *

Molasses as Fuel.

About 30 per cent. of the molasses produced in Queensland during 1928 was burnt as fuel in the bagasse furnaces. All the Northern mills reported that this could be done without serious difficulty, but some of the other mills had to abandon the attempt owing to clinkering. This seems to be due to the nature of the ash itself. Experiments carried out in Java in 1923 showed that when burning molasses alone it was possible to evaporate two lb. of water by burning one lb. of this by-product of 89 5° Brix. in a special furnace, the boiler efficiency of which was 150%. —(*International Sugar Journal*, Vol. 32, No. 376.)

REVIEWS.

Heredity in Live Stock.

By C. Wriedt. *Macmillan & Co.*, London, pp. 179. Price 7*s*. 6*d*.

Professor Punnett informs us in his introduction that this little book is in the nature of a legacy, and all who know anything of Wriedt's work on the genetics of the larger animals will appreciate how serious a loss that implies. We are indeed fortunate, however, in receiving such a legacy. As a geneticist with some small experience of stock breeding, the reviewer must confess that he did not know that so much work had been done on the genetics of the larger animals, and for lucid explanation and attractive composition Wriedt leaves little to be desired. Two obscure passages occur, which seem to require revision. On pages 5 and 6 we are told that " If short-eared and ear-less heterozygotes are crossed, both short-eared and ear-less offspring result." But " ear-less " animals are never heterozygotes ! On page 149 we are told that " English breeders (of poultry) were, and still are, on a " false scent," " whereas the context shows that their methods are the ones of which Wriedt approves, and their results are cited as a confirmation of his views. One misprint was noted—" bred " for " breed " on page 61.

There is only one criticism of major importance to make, and that is that the author is unduly optimistic about the simplicity of the inheritance of quantitative characters. He gives frequency diagrams of breadth of chest for parents, F_1s and F_2s of Rambouillet × Southdown sheep and of butterfat content for parents, F_1s and backcrosses of Red Danish × Jersey cattle, and in each case interprets his data as showing the effect of a single Mendelian factor. Experience with plants and animals more easily handled in large numbers shows how easy it is to obtain frequency distributions from small samples which fit a simple theory, and how often a larger sample gives a smooth curve which cannot be analysed into its components. Such a criticism is easy to make against those who work with the larger animals. You cannot have large families of large animals both because they are slow breeders and are expensive to keep, and it is an advance to have what facts are known about size inheritance and fat content brought together and discussed.

The large section of the book devoted to inbreeding is exceedingly good. The merits and dangers of inbreeding as a stockbreeder's method are discussed with a sanity of judgment that compels admiration.

The book is illustrated by photographs which were well chosen to give point to the text.

This is one of the very few books on genetics which can be thoroughly recommended to both stockbreeders and geneticists.

J. B. Hutchinson.

Insects, Ticks, Mites and Venomous Animals of medical and Veterinary Importance.

By W. S. Patton and A. M. Evans. *H. R. Grubb, Ltd, Croydon.* pp. 786. Price 20*s*.

In 1913 Patton and Cragg published their Text Book of Medical Entomology which has been a standard work on this subject. The volume under review replaces the former which is out of print and unavailable.

The book is intended primarily for the medical officer approaching for the first time the entomological side of his professional studies and has been written with particular reference to the course given in the Liverpool School of Tropical Medicine. The text is arranged to apply to 28 meetings of lectures on laboratory work and is illustrated by excellent drawings and photographs. When used as a text book at the Liverpool School appropriate specimens and notes on them are provided for practical work in the laboratory, the whole making it possible for the student to get the necessary facts in the shortest space of time.

As a text book in medical courses it will fill a most important place, and it will also be of value as a reference on the whole subject of insects and other arthropods in relation to the cause and spread of diseases.

The book has been published privately and is to be obtained only from the Entomological Department, Liverpool School of Tropical Medicine. The price includes packing and postage.

H. A. B.

* * *

The World's Grasses, their Differentiation, Distribution, Economics and Ecology.

By Professor J. W. Bews. 408 pp. London, *Longmans, Green & Co.* 21*s*. net.

A great wealth of information pertaining to the Gramineae has been collected together and arranged in this work ; morphological, taxonomic, economic, ecological and physiological. The information thus presented is of necessity, in a book of this size, more of a general nature and concerns the Family and Genus rather than the Species.

It is written especially from the point of view of the ecologist, and lays emphasis upon the part which environment has probably played in the evolution of the diverse forms existing at the present day.

All botanists will find this work of great use for reference purposes, and to the student who wishes to obtain a general knowledge of all the Genera of grasses, temperate and tropical, it will be invaluable.

R. E. H.

COLLEGE NEWS.

Mr. C. Y. Shephard, Professor of Economics, returned from Barbados on 3rd May, by s.s. *Venezuela*.

* * *

Mr. F. Hardy, Professor of Chemistry and Soil Science, returned from British Guiana on 4th May, by s.s. *Western Ocean*.

* * *

Mr. E. E. Cheesman, Professor of Botany and Genetics, left for England *via* Jamaica on the s.s. *Carare* on 3rd May on six months leave. As already announced he will represent the College at a number of Botanical Conferences.

* * *

Mr. P. E. Turner, Lecturer in Chemistry and Soil Science, left for England on four months' leave by the s.s. *Crynssen* on 29th April. Mr. Turner will represent the College at the meeting of Soil Scientists to be held at Rothamsted in September.

* * *

Amongst recent visitors to the College were Brigadier G. C. Grazebrook, C.M.G., D.S.O., Inspector-General of His Majesty's Forces in the West Indies, accompanied by Mrs. Grazebrook, Sir John Burdon, Governor of British Honduras, and Lady Burdon, Hon. H. F. Shand, Attorney of the Montserrat Co., Ltd., Montserrat; Major and Mrs. J. R. Boose, Royal Empire Society, London; and Mr. O. Emtage, Headmaster, Lodge School, Barbados, accompanied by Mrs. Emtage.

* * *

Capt. R. C. Petter who has recently visited Trinidad, has, on behalf of Messrs. Petter, Ltd., kindly offered to present the College with a 24 B.H.P. Vertical Twin Cylinder Petter "S" Type, Cold Starting, Direct Injection Oil Engine Plant. Messrs. Verity's of Birmingham have similarly offered to present the electric equipment for the whole plant. The engine will be installed in the College Experimental Factory. The grateful thanks of the College are offered to both donors. The value of the plant is £433 15*s*. 0*d*.

CACAO RESEARCH.

A SCHEME outlining the College programme for biological research into the Cacao crop was brought forward and formally approved by the Governing Body some two years ago.

The question of finance has been receiving attention during the period that has elapsed and naturally some difficulty was experienced. The financial situation has so far improved that the Colonial Office has announced that the Cacao Growing Colonies have now agreed to contribute towards the scheme in addition to certain of the more prominent Cocoa Manufacturing Firms. The contributions definitely promised so far are as follows:—

Capital.	
Trinidad	£ 1,200
Ceylon	100
Grenada	50
Cadbury Bros., Ltd.	1,000
J. S. Fry and Sons, Ltd. ..	500
	£ 2,850
Recurring for five years.	
Gold Coast Government ...	£1,000
Trinidad Government ..	600
Nigeria Government	500
Ceylon Government	50
Grenada Government ..	25
Cadbury Bros. Ltd.	500
Rowntree and Co. Ltd. ..	250
J. S. Fry and Sons Ltd. ...	200
	£ 3,125

As the capital so far raised is not quite sufficient to justify the purchase of a Cocoa Estate, it will be necessary to give further consideration to this matter, and it is believed that future aid in this direction will shortly be forthcoming.

The Governing Body meanwhile feels that much useful preliminary work can be done with the funds already available, and it has been decided that work should be started as soon as possible in the direction of:—

(*a*) Ascertaining whether cocoa could be propagated vegetatively.

(*b*) Picking out high yielding and disease free trees for grafting, &c.

(*c*) Investigating methods of fertilization and fruit formation.

(*d*) Investigations into Cacao soils especially with the view of studying ecological conditions.

A SPRAYING DEMONSTRATION.

THE machines shown during a recent spraying demonstration held at the College included gifts from The Four Oaks Spraying Machine Co.; Messrs. Cooper Pegler & Co.; Henry Milward & Co.; and various other pieces of apparatus for spraying and dusting. The machines ranged from simple atomizers and garden syringes to barrel and trunk sprayers, including knapsack sprayers; compressed air-knapsack sprayers with their own air compress, and compressed air knapsack sprayers with a central charging pump. Figure 1 (page x) shows a useful type of double-action pump on a platform of skids enabling the pump to be lifted from place to place for work in low-growing orchard trees and on rough ground, and Figure 2 shows in the foreground a similar type of pump, mounted on a two-wheeled truck suitable for use in orchards with level and smooth ground surface. Behind will be seen a variety of pumps of different types.

H. A. B.

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (*c.i.f.* per cwt.) :—

	Foreign.		*Preferential.*	
	s.	*d.*	*s.*	*d.*
27th March ..	7	6	11	0
3rd April ..	7	6¾	11	6¾
10th April ..	7	6	11	4½
17th April ..	7	6	11	3
24th April	7	6¾	11	3¾
1st May	7	5½	11	3
7th May	7	1½	11	0

Three events of considerable interest to the sugar trade have occurred: the publication of the Olivier and Watts Reports on the sugar industries of the West Indies and of Mauritius, the Budget and the decision arrived at Havana by the Stockholders to discontinue the Cuban Co-operative Export Agency. The latter two were uncertainties which had exerted a very unsettled influence in markets for some time. The Budget news caused little surprise as it was more and more evident that any change from the existing scale of tariff was unlikely. In spite, however, of the disappearance of political uncertainties and the approach of the period of heaviest consumption which might lead to more confidence in the future, markets generally have been in a somewhat undecided mood while there has been a disposition amongst trade buyers to await developments.

* * *

COTTON.—The following are the official Spot Prices in pence per lb. of the Liverpool Cotton Association :

	American Mid.	*Egyptian F. G. F. Sakel.*	*Sea Island.*		
			Good.	*Extra fine.*	*Prices paid this Week.*
28th Mar.	8·44	14·20	24·50	38·00	20·00-26·00
4th Apr.	8·85	14·20	24·50	38·00	29·00-32·00
11th Apr.	8·76	14·05	24·50	38·00	25·00
17th Apr.	8·61	14·25	24·50	38·00	27·00
7th May .... (local)	8·51	·	24·50	38·00	—

An improving tendency in prices has been shown for American which was maintained until the middle of April when rather quiet trading conditions prevailed and values declined. The Egyptian market has been somewhat irregular but on balance has shown little change. With regard to the prospects of the new American crop no reliable indications of conditions are available but it is believed that the acreage will probably be reduced.

* * *

COCOA.—Like most markets at the present time that for cocoa is very depressed. With absence of demand prices were sagging. Quite a contrast with this time last year when one of the largest manufacturers was prepared to buy everything.

* * *

COFFEE.—Prices of coffee have shown a tendency to fall. The market for robusta has been weak. Kenya has been consigning a quantity of "small but medium" coffee which has been lowering the standard, and sold at 80*s.* per cwt. Jamaica fine Blue has sold at 220*s.*; other averages include Costa Rica 140*s.*; Kenya 125*s.*; Santos 60*s.* to 65*s.*

* * *

TEA.—Restrictions on the quantities of leaves plucked for use as tea seem to have been agreed upon by the chief producing countries other than China. London returns for March showed a decided increase in quantities of tea taken by grocers and retailers. Latest averages for the week ending 19th April, were: Ceylon 22.08*d.* Indian 17.00*d.*; Darjeeling, 19.32*d.*; Assam 16.76*d.*; Java 10.76*d.* — (*Times Trade and Engineering Supplement*, 19th April.)

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows: 28th March, $7\frac{11}{16}d.$; 3rd April, $7\frac{5}{8}d$; 10th April, $7\frac{7}{16}d.$; 17th April, $7\frac{7}{16}d.$; 24th April, $7\frac{3}{16}d.$; 1st May, 7*d.*; 7th May, $6\frac{15}{16}d.$ Up to the middle of April the rubber market remained dull and inactive and according to *Messrs. Symington and Sinclair* appeared to have reached a condition in which the bullish and bearish features about balanced each other. Good support to the May tapping holiday scheme had been received up to 16th April.

* * *

BANANAS.—Jamaicas continue in good demand, and are unchanged to wholesalers at £22 10*s.* per ton delivered, or £22 per ton delivered nearest railway station, and to retailers at 10*d.* to 1*s.* per dozen (carriage extra). Brazilians are also in good demand and unchanged at £20 per ton delivered nearest railway station.—(*The West India Committee Circular*, 17th April.)

* * *

LIME PRODUCTS.—*Lime Oil.* Handpressed is valued nominally at 50*s.* per lb. There is no noticeable improvement in the demand for Distilled, and prices must be considered quite nominal. *Lime Juice.*—Concentrated is neglected, buyers are not interested and will not name a price as other raw material is plentiful. Small sales of fine Jamaica Raw have been made at 3*s.* 3*d.* per gallon.—(*The West India Committee Circular*, 17th April.)

THE SAMPLING OF CANE IN THE FIELD

BY

J. G. DAVIES, A.I.C.T.A.
Assistant Sugar Technologist.

Foreword.

It has long been recognised in sugar producing circles that considerable losses of sugar may result from reaping immature cane. Normally, the sucrose per cent. cane is lower during the opening and closing weeks than during the height of crop. To obtain the best yield of sugar, each field should be cut when it has attained its maximum growth and sucrose content. Although this is an ideal incapable of complete realization, efforts are made to select during the early part of the season those fields which are at or near their maximum sucrose content and to leave immature canes until later.

It is customary to determine the order of cutting either by the age and appearance of the cane or by taking a sample, consisting of a few stalks of cane cut in different parts of the field or one single stool, and analysing this in the laboratory. That these empirical methods are unsatisfactory is clearly indicated by the discrepancies which occur between the laboratory analysis and the actual milling results.

In the following paper an attempt has been made to place field sampling methods upon a sound statistical basis. The advantage claimed is that the sucrose per cent. cane of a field can be determined with a known degree of accuracy. The collection of a comparatively large sample is essential for accuracy but in order that laboratory grinding operations may be facilitated as much as possible, various methods of sub-sampling have been critically examined.

PART I.—THE SUB-SAMPLING OF CANE SAMPLES.

Introduction.

In recent years, it has become the general practice in the British West Indies to sample a field of cane by cutting one or more stools from that field, sub-sampling the sample so obtained and determining sucrose per cent. cane on the sub-sample in the laboratory. Various methods of sub-sampling have come to notice but few, if any, figures have yet been published as to the 'Standard Error' of any one method. It was thought that besides varying with the method of sub-sampling, the Standard Error might also vary with the conditions of laboratory milling. Two trials were therefore undertaken; in the first, sub-samples were ground in a small three-roller five inches by four and three-fourths inches handmill and in the second, the sub-samples were ground in a fairly large ten inches by fourteen inches power mill. Three methods of sub-sampling were examined. In Trial No. 1 five samples were sub-sampled by Methods Nos. 1 and 3 and ten samples by Method No. 2. In Trial No. 2 ten samples were sub-sampled by each of the three methods.

Methods of Sub-Sampling and Procedure.

The methods of sub-sampling which were examined are as follows:—

1. By Quadrants, in which each individual cane of the sample is cut through its entire length into four approximately equal parts.

When sampling by this method, the following procedure was adopted; a longitudinal cut was made down the cane, the piece to the left of the knife was cut again and went to form sub-samples Nos. 1 and 2 (the piece to the left to sub-sample No. 1 and the piece to the right to sub-sample No. 2). The piece to the right of the knife after the first cut was then cut again and went to form sub-samples Nos. 3 and 4.

2. By Halves, in which each individual cane of the sample is cut through its entire length into two approximately equal parts.

One longitudinal cut only is therefore necessary. In adopting a procedure similar to that described above, the piece to the left of the knife was placed on sub-sample No. 1 and the piece to the right on sub-sample No. 2.

3. By Thirds, in which the top of one cane is used, the middle of the next and the bottom of the next.

Each part of the cane was cut so as to be of approximately the same length as the other two. And each individual sub-sample consisted of as many tops as there were middles and bottoms (except of course, when the number of canes in the sample was not exactly divisible by three).

As a matter of convenience, one complete stool (except suckers) was cut and taken to represent a sample. This sample was then sub-sampled by one of the methods described above. Each sub-sample was weighed, ground (the bagasse from the first crushing being put through the mill again in treble layer) and analysed separately, the bagasse being weighed after grinding. Between the grinding of one sub-sample and the next, the mill was washed down as thoroughly as possible and the mill bed, juice gutter, &c., mopped dry with a cloth.

The bagasse was sampled by tearing each piece longitudinally into two, one half being retained and the other discarded. The half that had been retained was chopped up into small pieces (quarter inch), the chips thoroughly mixed and sent to the laboratory. Sucrose per cent. juice was determined by Horne's Dry Lead method and sucrose per cent. bagasse by the method of single digestion of fifty grams. Weight of sucrose in both juice and bagasse was then calculated together with the sucrose per cent. cane in the sub-sample.

Statistical.

The results (sucrose per cent. cane) for each method of sub-sampling were then tabulated, each of the Trials separately. The mean of the first sample and the deviation of each of its sub-samples from this mean were then calculated, the deviation next being squared in order to eliminate the plus and minus signs. This process was repeated with each of the other samples. The 'Deviation Squared' column was then summed and the 'Variance' and 'Standard Error' calculated. The Variance was taken to be $\frac{(\text{Sum of Deviation})^2}{\text{Degrees of Freedom}}$ and Standard Error as $\sqrt{\text{Variance}}$. A full and lucid explanation of these statistical terms is given by Maskell.[1]

The following is a summary of the results obtained :—

Table 1.

	No. Stools used.		Standard Error of all sub-samples from mean of their stool (Suc. per cent. Cane.)	
	Trial 1.	Trial 2.	Trial 1.	Trial 2.
By Quadrants (Longitudinal cut)	5	10	0·234	0·284
By Halves (Longitudinal cut)	10	10	0·357	0·341
By Thirds (Transverse cut)	5	10	0·725	0·812

It was then necessary to test whether the Standard Errors were significantly different from one another (for method, see Fisher[2]). The following is a summary of this test :—

Table 2.

TRIAL No. 1.

Method.	Degrees of Freedom.	Standard Error.	Log_e S.E. x 10.	Difference of logs.		Z required.	
						P = ·05	P = ·01
1. (Q)	15	0·234	·85015				
2. (H)	10	0·357	1·17257	H-Q	·42242	·523	
				Th-Q	1·13085	·4657	·6937
3. (Th)	10	0·725	1·98100	Th-H	·70843	·5611	

Table 3.

TRIAL No. 2.

Method.	Degrees of Freedom.	Standard Error.	Log_e S.E. x 10	Difference of logs.		Z required.	
						P = ·05	P = ·01
1. (Q)	30	0·284	1·0438				
2. (H)	10	0·341	1·2267	H-Q	·1829	3·691	
3. (Th)	20	0·812	2·0943	Th-H	·8676		·77

Discussion.

Methods of sub-sampling cane may be judged from three standpoints :—

1. Time taken to carry out the sub-sampling.
2. Accuracy of the method.
3. Weight of sample that can be represented by a given weight of sub-sample.

1. *Time Taken.*

Ordinary laboratory routine demands that the method be fairly rapid. Of the three examined, No. 3 occupies the shortest time, then No. 2 and, finally No. 1. The total difference in time between No. 3 and No. 1 is not, however, very great but it is appreciable and must be taken into consideration when large numbers of samples are to be dealt with.

2. *Accuracy of the Methods.*

Table No. 1 sets out the Standard Errors of each method in both trials. It is remarkable how close the figures for each of the methods in Trial No. 1 are to Trial No. 2. The Standard Errors indicated include the error of sub-sampling the sample, the error due to sampling bagasse and the error in the laboratory analysis. Judging on the basis of these statistical results, methods Nos. 1 and 2 are more accurate than method No. 3. To a certain extent this was as expected since in methods Nos. 1 and 2 part of the entire length of each cane in the sample is represented in the sub-sample whereas in method No. 3 only part of each cane is used for the sub-sample.

The statistical procedure shown in Tables Nos. 2 and 3 indicates that while there is no significance between the Standard Errors of methods Nos. 1 and 2, there is a significant difference between these figures and the Standard Error of method No. 3. Discarding method No. 3 for all but very rough analyses, each of the other two methods offers different advantages. Method No. 1 enables conveniently sized sub-samples to be used to examine large samples of cane while method No. 2 is fairly rapid and its Standard Error is not significantly different from that of method No. 1. Method No. 1 is therefore suggested as suitable for use in sub-sampling the samples from an experimental plot and method No. 2 as suitable for the ordinary routine analysis. Method No. 3 may be used if only a very rough idea of the analysis of a sample is required. It must also be remembered, however, that the canes must be sent in whole when this latter method of sub-sampling is used. This may lead to inconvenience in transport from the field to the laboratory.

3. *Size of Sub-Sample Obtained.*

The weight of a sub-sample must be considered because of the difficulty in obtaining a representative sample of bagasse. It follows that the lower the weight of this sub-sample, the lower the weight of the bagasse and therefore the lower the error in sampling that bagasse for analysis. No. 1 method is the most efficient from this point of view.

Summary.

1. Three methods of sub-sampling have been examined under widely different conditions of laboratory milling.

2. The statistical results show that cutting each cane longitudinally into four and using one of the quadrants so obtained is not significantly more accurate than cutting each cane longitudinally into two. Both of these methods are, in turn, significantly more accurate than cutting each cane transversely into three.

3. The size of the laboratory mill in which the sub-sample is ground does not affect the Standard Error to any large extent.

4. Method No. 1 is suggested as suitable for use in sub-sampling the sample from an experimental plot, that is, in cases when it is necessary to take a large sample for sub-sampling.

5. Method No. 2 is suggested for use in ordinary routine work, *e.g.*, in determining degree of ripeness of a field.

6. Method No. 3 is the most rapid but at the same time least accurate and is therefore suggested as only suitable for very rough estimations.

PART II.—ERROR OF SAMPLING CANE FIELDS BY THE STOOL.

Introduction.

With the conclusion of the investigation on sub-sampling methods the second part of the work was commenced—that of obtaining data on the sampling of a cane field by the stool. Mr. W. Scott, Chief Chemist of Usine Ste. Madeleine, and Professor of Sugar Technology at the Imperial College of Tropical Agriculture was the first to institute the idea in Trinidad of sampling a field by cutting a complete stool from that field instead of a number of separate canes from different stools. No real system is followed in the collection of such samples and it is usually left to the discretion of the Overseer as to which stool is sent in to the laboratory for analysis. The method nevertheless has advantages, the chief of which is that all temptation is removed to cut only ripe canes. A stool must of necessity consist of a number of canes of different ages. Hence the sample will contain a very fair proportion of mother shoots and side stalks. On the other hand, the temptation is ever present only to cut good stools. It is practically impossible to judge a field of cane and then select one single stool to represent the whole. This work was therefore organized with a view to finding out (1) what is the variation in sucrose per cent. cane from one stool to another, and (2) what is the Standard Error of samples which consist of varying numbers of stools collected at random. While a certain amount of statistics is necessary for the working out of the results, complicated statistical procedures have been avoided as much as possible.

Review of the Literature.

Considering the important bearing that the sampling of cane fields has on the economic running of a sugar concern, very little literature has yet been published on the subject. Leather [3] carried out a series of experiments in 1913 in India. He took a cane stalk as his unit and the method of collection was to measure a specified distance along the end of the rows in the field and then another specified distance along the line of the rows. The three canes that came nearest to the measured point were then cut and collected. The sample altogether consisted of about 200 canes collected in lots of three. Approximately 70 different parts of the field were therefore visited. The result of the investigation was that in plots from one-tenth of an acre to one acre in extent, the variation due to "plant" was greater than the variation due to "soil." Annett [4], also working in India, confirmed these results and states that of the three methods of sampling that he examined, the method laid down by Leather gave the most accurate results. Kobus [5] states that "the sugar content of different well developed and equal aged shoots of the same stool can sometimes show great differences and

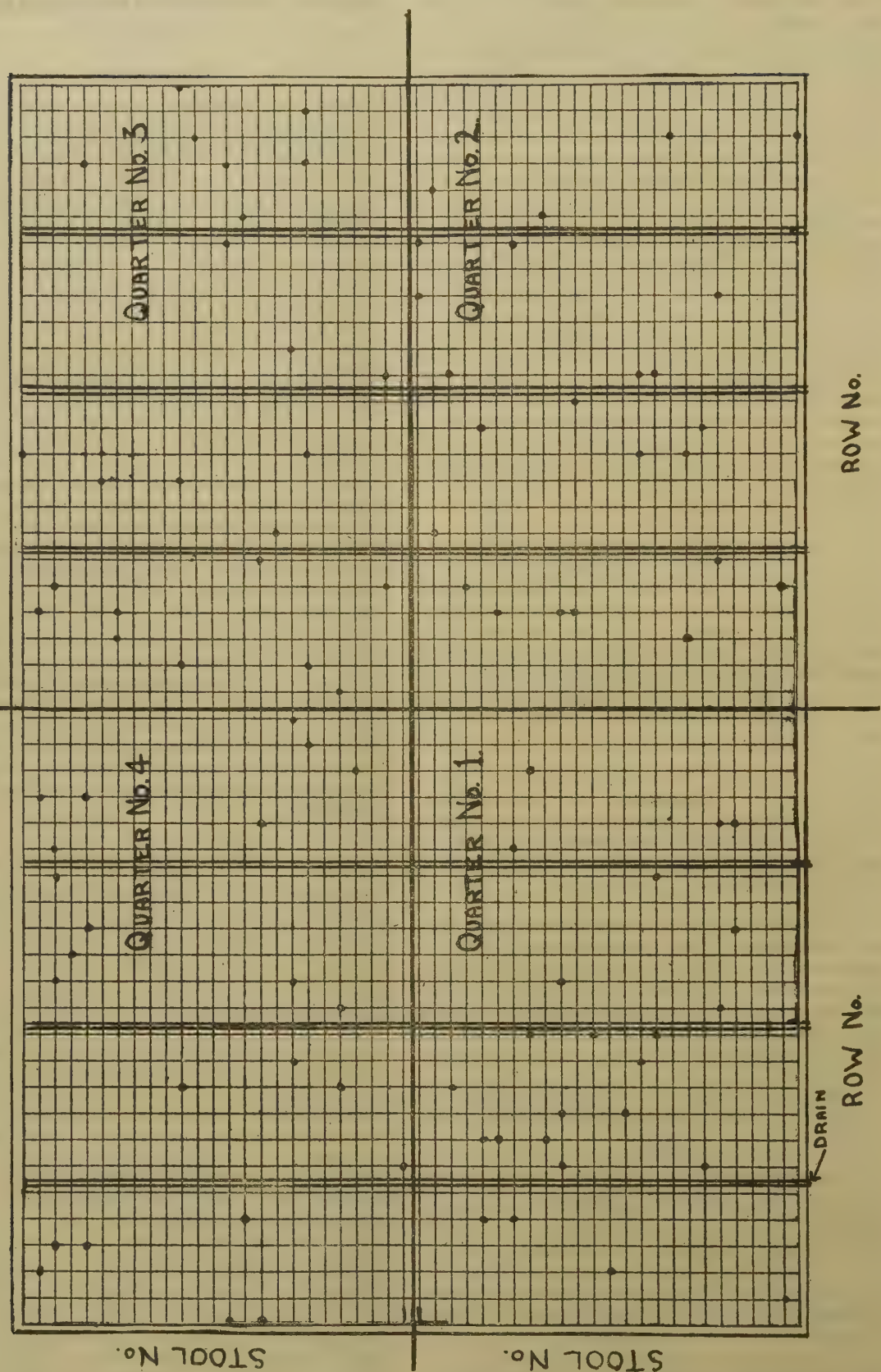
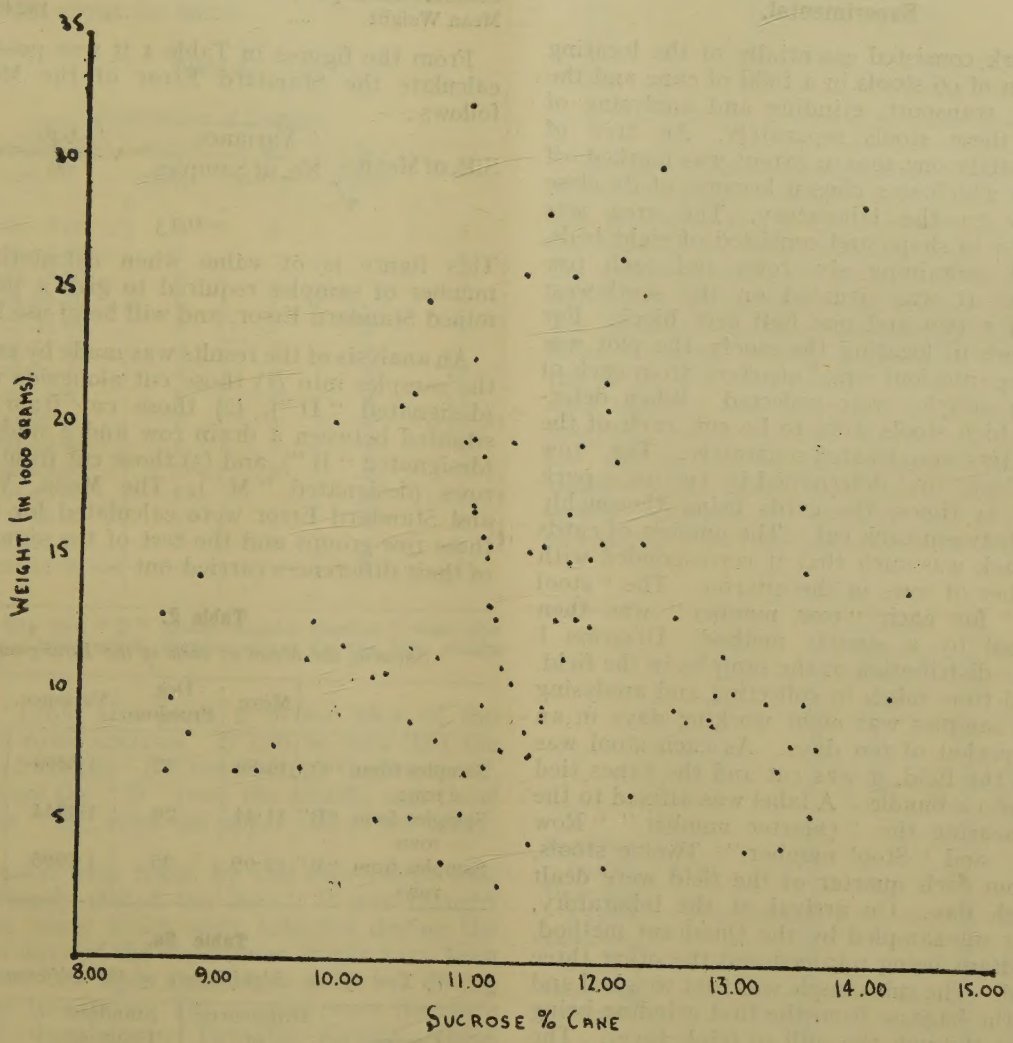


Diagram I.—Distribution of the random samples through the field.

Diagram II.—Weight and sucrose % cane of each of the stools.



at other times be pretty much alike," and he gives figures to substantiate this conclusion. In view of this, he decided to test the whole stool for his work on selection. It would therefore seem fairly sound practice to take the complete stool (as cut for the factory) as the unit to make up the sample.

Experimental.

The work consisted essentially of the locating at random of 96 stools in a field of cane and the collection, transport, grinding and analysing of each of these stools separately. An area of approximately one acre in extent was marked off in a field which was chosen because of its close proximity to the laboratory. The area was rectangular in shape and consisted of eight beds, each bed containing six rows and each row 50 stools. It was situated on the south-west corner of a two and one half acre block. For convenience in locating the stools, the plot was divided up into four equal quarters, from each of which 24 samples were collected. When determining which stools were to be cut, each of the four quarters were treated separately. The "row number" was first determined by cutting a pack of cards 24 times, the cards being thoroughly shuffled between each cut. The number of cards in the pack was such that it corresponded with the number of rows in the quarter. The "stool number" for each "row number" was then determined by a similar method. Diagram I shows the distribution of the samples in the field. The total time taken in collecting and analysing these 96 samples was eight working days in an over-all period of ten days. As each stool was found in the field, it was cut and the canes tied tightly into a bundle. A label was affixed to the bundle bearing the "Quarter number," "Row number" and "Stool number." Twelve stools, three from each quarter of the field were dealt with each day. On arrival at the laboratory, each was sub-sampled by the Quadrant method, one quadrant being retained and the other three discarded. The sub-sample was first weighed and ground, the bagasse from the first grinding being again put through the mill in triple layer. The final bagasse was sub-sampled and the sub-sample chopped up into quarter inch chips, the chips thoroughly mixed and sent to the laboratory. Sucrose per cent. cane was determined by the same methods as those previously described.

Results.

The lowest sucrose per cent. cane that was recorded was 8.62 and the highest 14.28, while the lowest weight that was recorded was 2,896 grams and the highest 33,512 grams. Diagram No. II shows the weight and sucrose per cent. cane of each of the stools. It appears that there is no relationship between these two factors.

Statistical Treatment.

The Arithmetic Mean, Variance and Standard Error were calculated for the whole sample. The results are set out in Table 1.

Table 1.

Mean Sucrose per cent. Cane	11·46
Variance	1·6467
Standard Error	1·283
Standard Error per cent. Mean	11·19
Mean Weight	13240 gr.

From the figures in Table 1 it was possible to calculate the Standard Error of the Mean as follows :—

$$\text{S.E. of Mean} = \sqrt{\frac{\text{Variance}}{\text{No. of Samples}}} = \sqrt{\frac{1.646}{96}} = \sqrt{0.017}$$

$$= 0.13$$

This figure is of value when calculating the number of samples required to give a predetermined Standard Error, and will be of use later.

An analysis of the results was made by grouping the samples into (1) those cut alongside a drain (designated "D"), (2) those cut from a row situated between a drain row and a middle row (designated "B"), and (3) those cut from middle rows (designated "M"). The Mean, Variance and Standard Error were calculated for each of these row-groups and the test of the significance of their differences carried out :—

Table 2.

Showing the Mean of each of the Row-groups.

	Mean.	Deg. Freedom.	Variance.	Stand. Error.
Samples from "D" rows	10·80	32	1·6469	1·28
Samples from "B" rows	11·44	26	1·4344	1·20
Samples from "M" rows	12·09	35	1·1095	1·05

Table 2a.

Test of the Significance of the Differences.

Groups.	Differences of Means.	Standard Error of Differences.	"t."
M-D	1·29	·28	4·54
M-B	·65	·29	2·24
B-D	·64	·32	2·00

"t" is the ratio of the observed difference to its Standard Error. Should the ratio be greater than two, then the difference is considered significant.

The difference between the mean of one group and the mean of each of the other two is therefore significant in each of the three cases. In view of these results, any samples collected from a field

must be fairly evenly distributed between each of the three groups. Actually in this experiment the ratios were 33 : 27 : 36, which is very near a theoretical distribution since, in the field, there was an equal number of stools in each of the three groups.

A Distribution Table was constructed with a view to determining how the samples arrayed themselves about the Mean.

Table 3.

Distribution of Samples.

Sucrose per cent. Cane.	"D" group.	"B" group.	"M" group.	Total.
8·61- 9·00	3	2	—	5
9·01- 9·40	2	—	—	2
9·41- 9·80	3	—	—	3
9·81-10·20	1	1	—	2
10·21-10·60	5	2	2	9
10·61-11·00	6	3	2	11
11·01-11·40	6	5	5	16
11·41-11·80	1	4	8	13
11·81-12·20	1	5	4	10
12·21-12·60	1	1	3	5
12·61-13·00	2	2	3	7
13·01-13·40	1*	—	3	4
13·41-13·80	1*	1	4	6
13·81-14·20	—	1	1	2
14·21-14·60	—	—	1	1

Note.—The two "D" group samples marked * were also alongside a trace which might account for the high results obtained.

This Table also gives a better idea of the grouped rows analysis. It can be seen that the samples from the "D" rows occupy the lower end, those from the "B" rows the middle, and those from the "M" rows the upper end of the array.

The total time taken by the experiment was, as previously stated, ten days. It was thought that the canes which were collected during the last two days of the experiment might have been comparatively riper than those collected during the first two days. The samples were therefore grouped together in Two-Day Groups, those collected on Days 1 and 2 forming Group 1, on Days 3 and 4 Group 2, and so on. The Mean of each of these Groups was determined and the significance of the differences calculated. The tabulated results follow :—

Table 4.

Showing the Mean of the Two-Day Groups.

Group.	Mean.	Variance.	Degrees of Freedom.	Standard Error.
No. 1	10·86	1·1966	23	1·09
No. 2	11·90	1·3235	23	1·15
No. 3	11·16	1·0267	23	1·01
No. 4	11·90	2·3659	23	1·54

Table 4a.

Significance of the Difference of the Means of the Two-Day Groups.

Groups.	Difference of the Means.	Standard Error of Difference.	"t"
4-1	1·04	·38	2·74
4-3	·74	·38	1·94
2-3	·74	·31	2·38
2-1	1·04	·33	3·15
3-1	·30	·30	1·00

The differences of the Mean of Group 1 and the Means of Groups 2 and 4 are therefore significant and the difference of the Mean of Group 1 and the Mean of Group 3 is not significant. Similarly, the difference between Group 2 and Group 3 is significant, and also between Group 3 and Group 4. The Means of Groups 2 and 4 are the same. The Mean of Group 1 being significantly smaller than the Means of Groups 2 and 4 might suggest that some ripening had taken place. It was thought, however, that in view of the grouped rows results, the distribution of the samples among these Groups might have affected the grouped days results. In order to test this, the two methods of analysis were combined as shown in Table 5.

Table 5.

	Alongside Drains. (D).		Between Drain and Middle Rows (B)		Middle Rows (M).	
	No. Samples	Mean	No. Samples	Mean	No. Samples	Mean
Days Nos. 1 and 2	12	10·20	4	11·28	8	11·51
Days Nos. 3 and 4	4	11·07	9	11·77	11	12·32
Days Nos. 5 and 6	9	10·51	6	11·22	9	11·79
Days Nos. 7 and 8	8	11·72	8	11·33	8	12·65

Discussion.

(1) *Variation from Stool to Stool.*

An inspection of Diagram 2 will reveal the fact that when a larger number of stools are collected at random from a field of cane, there is considerable variation from one stool to the next both in weight of stool and sucrose per cent. cane. The Standard Error of the population as recorded in Table 1, is fairly large and the Distribution Table, Table 3, shows that the majority of the samples fall within the Standard Error, *i.e.*, 1.283 either side of the Mean. In a Normal Distribution, the probability of any one value occurring falls off as the deviation of this value from the Mean increases. Twice the Standard Error is exceeded only about once in every 22 trials and thrice the

Standard Error only once in 370 trials. In the Distribution Table under discussion, twice the Standard Error is exceeded five times in 96 trials or once in every 20. It may therefore be considered a very fair distribution.

Table 5 shows that in nearly every Two-Day group, the Mean of the samples collected from the middle rows is greater than those collected from rows situated between drain rows and middle rows and the Mean of the samples collected from these " Between " rows is, in turn, greater than those collected from the drain rows. The Distribution Table also shows the distribution of these samples within the general array.

To determine whether there had been any significant ripening during the course of the collecting and analysing of the samples, it was necessary to test the significance of the differences of the Means of each of the Two-Day groups in each of the row groups. The procedure is set out in Fisher [6] and the results of these calculations are shown in Table No. 6.

Table 6.

	Alongside Drains.	Between Rows.	Middle Rows.
Day Groups.	4.	4.	4.
1	Significant	Not Signif.	Significant.
2	Not Signif.	do.	Not Signif.
3	do.	do.	do.

In view of these results, it seems that while ripening might have taken place, the degrees of significance were such that the value of the experiment is not lessened to any great extent.

(2) *Number of Stools to the Sample.*

The Standard Error of the Mean of a sample of cane is the value by which this Mean is likely to vary from the Mean of the entire field. In this experiment, a large sample consisting of 96 stools was collected at random. The Mean of the sample was 11.46 sucrose per cent. cane and the Standard Error of the Mean 0.13. The sample that was collected was therefore a very fair representative of the field. It is next necessary to determine how many stools must be collected *at random* so that the Standard Error of the Mean of these stools is within predetermined limits of the true Mean of the field. In doing this, it must be remembered that for a difference to be significant, it must have a value of at least twice its Standard Error. Supposing, therefore, it is necessary to distinguish a difference of 0.75 sucrose per cent. cane in two samples from two different fields, the Standard Error of the difference of the Means must not be greater than 0.375. The number of stools to be collected at random to make up each of these samples is then calculated by the method set out in Fisher [7]. The value for P=.05 in the Table of " t " has been used in every case. The following are the numbers of stools necessary to give the predetermined Standard Errors ;—

Standard Error of Mean (Sucrose % Cane.)	*No. of Stools required per sample.*
1.80	4
1.00	9
0.75	15
0.50	28

Summary.

1. Ninety-six stools were collected at random from a field of sugar-cane. Each stool was weighed, ground and analysed separately.

2. The stools showed considerable variation both in weight and sucrose per cent. cane.

3. The Standard Error of the Mean of the 96 stools was small, showing that a sample of this magnitude gives a very fair basis to work on.

4. Those stools collected from drain rows were significantly lower in sucrose per cent. cane than those collected from rows between drain rows and middle rows and the stools collected from these " between " rows were lower in sucrose per cent. cane than those collected from the middle rows.

5. The number of stools per acre that must be collected at random to give a predetermined Standard Error has been calculated.

Application.

It is the aim of every sugar manufacturer to reduce to a minimum the losses of sugar consequent upon the cutting of immature cane. In this paper, a method has been demonstrated that enables the sucrose content of a field of canes to be ascertained with a known degree of accuracy. It is recognized that slightly increased laboratory expenditure will be necessitated by this method but it is claimed that it will enable the order of cutting to be determined in a manner which will reduce to a minimum the loss of sugar inevitable with the existing empirical methods. It is further claimed that the additional sugar recovered will leave an appreciable margin of profit after deducting the increased laboratory expenses.

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